The English

GIOBE

Being a STABIL and Immobil one, performing what the Ordinary Globes do, and much more.

Invented and Described by the Right Honourable, the Earl of Castlemain.

The Second Edition.

Corrected by J. Moxon, Member of the ROYAL SOCIETY.

Fundasti TERRAM super STABILITATE sua, Psal. 104. 5.

LONDON,

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TO THE

READER

Concerning this Globe, and the occa-fion of the Inventing of it.

FEW and profitable Inventions in Arts are like hidden Treasures found, which ought not to be reburied, and concealed again, but dispersed and made use of for the common good. This Globe then, and its Description (which I have humbly obtained from the Right Honorable, the Earl of Castlemaine) being both highly curious and useful, I thought I could not better serve (as I have always endeavoured) this, and future Ages, then by communicating it to them; and because the occasion of the Invention is so accidental, and (as it proves) so happy, I shall give you a short account of it.

Waiting upon my Lord in the beginning of Anno 1672, at his then arrival into England, I brought his Lordship (knowing that any thing new and ingenious would be acceptable to him) one of my 3 Inch Terrestrial Globes, with the Stars described in the inside of its Case, which when his Lordship had considered, and bin inform'd by me, that its only Use was to keep in memory the fituation of Countries, and Order of the Constellations and particular Stars, He intimated, that certainly much more might be done by it, and so returning beyond Sea fell

upon this excellent Work.

When he came home again (which happned above a year ago) and was pleased to shew me what he had done, I was as much ravisht and suprised at the admirable Contrivance of his Globe, and the many unexpected Operations performed by it, as if I had bin a new Beginner in the Study of the Sphere;

To the Reader.

Nor could my admiration be less, when I saw how (without the usual assistance of a Meridian Line, Mariners Compass, or other such helps) it composed it self to the true site and position of the World; how that in an instant, the Suns Altitude was naturally and plainly found by it, and this in all places of the World at the same time; Nor did it seem less strange to me, that so many curious Questions relating to Eclipses should be resolved by it, and what is more that Altimetry could possibly have any relation to a Globe. Besides, I saw that not only the Practical part of Dialling was now rendred easy to a wonder, but the Theorical also so plain, that every mean capacity might streight comprehend it; Nay, all the forrain Requisites to this Art (as the Declination of Planes, their Inclination, Reclination, &c.) are here as artificially and exactly found, as by

any Instrument invented for that intent alone.

And this I can also say, that as to the Geographical part, it is (considering its bigness) not only the most useful, but also the best order'd and the best divided Globe extant; and yet it would have bin not a little better, had not his Lordships late Troubles hinder'd him from finishing it, as he design'd; for Directions are not always sufficient to express an Authors mind. But truly notwith-Standing these and other prodigious Operations, that which surprised me with the most admiration was to sind, that in a subjest so trite as the Globe (and so nicely Canvast by the greatest Mathematicians of all Ages) any thing Should be left to be added or invented to it; which also shews that the Wit of Man has no bounds; nor can any thing better demonstrate the noble Authors great Parts, who moreover (because he would omit nothing that I had offered at in the Proto-type) has here shew'd his excellent skill in relation to the Stars by a Proje-Etion on the Pedestal; and doubtless this kind of Projection was never brought to that perfection before.

But Gentle Reader, I shall injure you too much if I detain you longer from this rare present, and therefore after rendring again my thanks to his Honour for this favour and libertie,

I subscribe my self

June 24. 1679.

His and Your Humble Servant,

Joseph Moxon.

A Postscript concerning the Erratas, and the Geographical part of this GLOBE.

The Erratas of the Press being many, I shall not set them down in a distinct Catalogue as usually, least the sight of them should more displease, than the particulars advantage, especially since they are not so material or intricate, but that any man may (I hope) easily mend them in the very reading. I consess I have bin in a manner the occasion of them, by taking from the Noble Anthor a very soul Copy, when he desir'd me to stay till a sair one were written over, so that truly 'tis no wonder, if Workmen should in these cases not only sometimes leave out, but adde also, by taking one line for another, or not observing with exactness what words have bin wholly obliterated and dasht out.

As to the Geographical part of the Globe be pleased to take notice that ist, The Terms or Bounds betwixt EUROPE and ASIA, or between ASIA and AFRICA, are Strokes and Pricks = = = thus: between great Empires, single Strokes in this manner ---; and between Province and Province only Pricks. And by the way, the Author calls here an Empire, every great Tract of ground of one Appellation, as Barbary and Zara in Affric, Siam and Pegu in Asia, Italy and Germany in Europe, as well as France, Spain, Persia, &c. that belong to one only Prince. These Empires are in little Capital Letters, but the Provinces or Subdivided Kingdoms are in Round Roman, as Algiers and Tunis in BARBARY, Pomeren and Austria in GERMANY, &c. and for the Towns as London, Paris; Venice, &c. they are generally in Italick, but when they happen to be in Round Roman, as Fez; Morocco, Agra, &c. it shews that the Province gives the Name to the Capital City; for the Name properly belongs to the Province, but to fave trouble and room it is now by a Reference or Dash joyn'd to the Town.

2. The Old Name of any place is in Old Hand, and when

Ethiopia, &c. when a Province, a great deal less, as Mesopotamia, Caldea, Asspria and the like, and when a Town very little, as Dippo, Oprene, and so forth.

3. The Hills that are express have all before them the Letter M, and the Capes the Letter C, but the Rivers have eithe either an R or else fl. after them; and whereas some Old names, as Thule, Ophir, &c. are repeated, it is to shew where One Author would have their situation to be, and where Another.

* pag. 24.

But be pleas'd to remember, that whereas his Lordship did Direct in this * Treatise, that the Grand Meridian should pass throu' St. Vincent, I have presum'd to draw it over St. Mary and St. Michael, 2 Isles of the Azores; for truly thus it suits best (according to my Tables) with the 2 a Clock Circle, as his Lordship would have it do.

An Advertisement.

Because there are several who either want time, or Patience to go throu' the whole Treatise, I here present the Reader with a Catalogue of the Operations, which are most pleasing and suitable to the fancy and humour of such, and which they may easily in a day or two learn, especially if they have a Master to help them.

TO set the Globe level. pag. 4.
2. To compose the Globe. p. 8.

3. To know the day of the Month. p. 9.

4. To take the Suns height above our Horizon, when he shines out clear; and also when he shines dimly, and is overclouded, p. 5. and 6.

5. To find the Suns Azimuth and Bearing. p. 10 and 12.

6. To know the Hour several ways. p. 13.

7. To know at what hour the Sun rifes or sets. p. 16.

8. To know what a Clock 'tis all the World over. p. 31.

9. To find where 'tis day and where 'tis night all the World over. p. 33.

Day, and where (at that moment) they have nothing but Day, and where nothing but Night; as also when this happens in any place subject to this Alteration. p. 33.

11. To find the Sun's present Height and Depression all the

World over, if he Shines. p. 37.

12. To find where the Sun is rising and setting all the World over. p. 34.

13. To find what people have then the Sun Vertical, or over

their heads. p. 35.

14. To know where they are rising, where they are going to Dinner, where to Supper, and where to Bed all the World

over. p. 35.

are past Morning, or want of Evening; and (if it be Night with them) how much they are past Evening and want of morning; and consequently the Babilonish and Italian Hour all the World over, p. 36.

16. To know the Judaic Hour, p. 39.

17. To find in what Clime any Place lyes. p. 26.

18. To know in any Lunar Ectipse, what Countries see it wholly, what in part, and what not at all; as also the true hour, which each people see her at, in her several Affections; with her continual Height, Azimuth, and Bearing all the while. p.59.

19. To represent the several Phases of the Moon. p. 61.
20. To find the Proportion between any Perpendicular and

it's shade. p. 65.

21. To take the height of a Tower by the Globe. p. 66. 22. To do it seemingly without any Instrument. p. 66.

23. To know the Hour by your Stick. p. 67.

- 24. To learn presently how to make (all the 5 Dials of a Cube, (to wit, that on its * Horizontal, that on its direct † South, *p.73.†p.80. that on its direct * North, that on its direct † East, and that on *p.82.†p.85. its direct West Plane) the a man be never so unacquainted with Mathematics.
- 25. To represent at any time the posture of the Heavens in relation to the appearing Fixt Stars; and consequently to find the present Hour, with the Height, Azimuth and Bearing of any Star; as also the time of its Rising, Setting and continuance both above and below the Horizon. p. 138.

The

The General Heads.

1. THE Figure, or Delineation of this Globe, as also an account of it, and the occupion of its Invention, together with a Catalogue of the Operations fittest for those that cannot run over the whole Treatise, are contained in the unfigured or preceeding pages.

2. The Introduction begins pag. 1.

3. The first Section, solving the Questions which relate to the Sun in our Elevation. p. 4.

4. The second Section, resolving the Operations that concern

Geography, and the Sun all the World over. p.20.

5. The third Section, concerning the Moon, p. 48.

6. The Fourth Section relating to Perpendiculars and their Shades. p. 64.

7. The Fifth Section treating of Dialling.p. 70.

The Figure of the Globe fitted for a Garden or open Portico. p. 121.

Geometrical Problems, necessary for Dialling. p. 122.

8. The Use of the Line of Lines, and Line of Sines on the Sector. p. 125. & 127.

9. The fixth Section, solving (both by the Globe and Pedestal) all the usual Questions which relate to the Stars, p. 129. & 135.

The Explication of the Letters, &c. on Sch. 1.

P. The North Pole of the World.
N. The Northern Polar Circle.
Z. The Zenith.
E E. The Ecliptic.

May 1. The Parallel of that day.

Apr. 1. The Parallel of that day.

Apr. 1. The Parallel of that day.

Apr. 1. The Parallel of that day.

E. The Equator.

Mar. I. The Parallel of that day. Feb. 1. The Parallel of that day. Jan. 1 The Parallel of that day. Wy. The Tropic of Capricorn. H 19. The Horizon.

S. The Southern Polar Circle.

1 The South Pole.

The Nadir. ZH. The Quadrant of Altitude:

The Quadrant of Depression.

Z.D. The Quadrant of Pro-

PAD. The Meridian of the Place or Solstitial Colure.
LL The Meridian of the World.

P. D. The Equinoctial Colure.

X II. I.II.&c. The Hour Circles, or particular Meridians.

THE

Introduction.

HIS Globe whose several Operations we are here describing, neither hangs in a Frame, nor is moved about as the ordinary ones are, but stands stable and immobil on its Pedestal. which makes it not only to represent the Earth more naturally, according to the common Hypothesis, but renders it also more expedite and useful, as shall be fully shewn in the Conclusion or last Chapter; for then (after a view of the whole Treatife) every body will the better comprehend all the new Operations it performs, and all the particular Advantages, it can any ways challenge to its self. But here my Reader must remember that though I endeavour all along (even in the most ordinary things) to be clear and eafy, yet unless he has formerly read, Hewes, Bleau, or rather Moxons Book on the Globes, I cannot promise him I shall always be understood without the help of a Master; for I have not time to descend to all the Definitions and minute Explanations, which those that are wholly unacquainted with Astronomical or Geographical Principles, may perchance expect.

As for the Circles here describ'd, there are some common of the Circles to all Globes; as the Aquator, the Ecliptick, the Coluri, the describ'd on ordinary Circles of Longitude, the Tropics, and the Polar Circles Globe. cles; and some also particular to this Globe only, as the Horizon, the Meridian of the Place, and 16 Parallels to the Aquator, all within the said Tropics. Now that these Circles in general may be the sooner sound and comprehended by any new Beginner, there are Capital Letters in the Great Figure, or Delineation of the Globe, in Scheme the sirst, which sufficiently di-

itinguith

stinguish them; for the Aquator is markt with A, the Ecliptic with E, the Polar Circles with N. and S. The Circles of Longitude with the Roman Figures, I. II. III. &c. as well where they fall. upon the Polar Circles, as the Equator; and tho all the Circles, that thus cut the Aguator and Polar Circles at a Roman Figure be Circles of Longitude, yet they now serve for true Hour Circles also, since they are not here express'd, and drawn (according to the usual manner of Terrestrial Globes) at the distance of 10 Degrees, but of 15 asunder. And here be pleas'd to remember that fince there is a difference between the Roman Figures which belong to the same Circle (for if it cuts for example at IIII. on the Polar Circles, 'twil cut, you see at six hours difference, vi7 at X in the Aquator,) the reason of it will appear by and by very plainly when we come to the Operations, that concern these Circles; of which the broadest (passing through the Zenith and Nadir) has two Quadrants gradually divided on one half of it, the first called the Quadrant of Altitude, reaching from the Pin Z or Zenith, to the Horizon H, the second (called the Quadrant of Depression) reaching from thence to the Nadir; whereas on the other half, or back part of the said Circle, there is a single Quadrant only, viz. from the Zenith to the Horizon, which we shall for the suture term the Quadrant of Proportion. This Circle is also markt on the Polar Circles with the Figure XII. representing thereby, not only the 12 a Clock bour Circle or Meridian of the place, for which the Globe is particularly design'd, but the Colurus Solfitiorum also; so that the Colurus Aguinoctiorum must be the 6 a Clock (ircle, whose half is (as you see) divided for several uses into Degrees from Pole to Pole. By these two Circles then, you have readily presented to you the 4 Cardinal Settinal points of ons, or Points of the Globe; for as the Graduated half of the said Meridian, shews the Globes Southern part or face, and the opposite its Northern, so the graduated half of the fix a Clock Gircle gives its Eastern, and the plain side of it its Western. Now for the Aguinoctial Parallels, or Sun's Track for every roth day, throughout the year, (for to avoid Confusion of Circles, I describe no more) they are distinguish'd by the Days of the Month, when the Sun comes to them; the uttermost of which are the two Tropics markt not only with the 11th of Jane and 1 1th. of December, but with and w, the usual Characters

The 4 Cardi-

racters of Cancer and Capricorn. Lastly, for the Meridian of the World, or first Circle of Longitude, 'tis markt with the Letter L, and prickt also, and tho in the present Longitude (i. e. that of London) it stands for the 2 a Clock Hour-Circle, yet in its felf 'tis changeable, as shall be shewn hereafter, when we * vid. Oper. treat of its * Properties, and Divisions.

These are then the Circles here describ'd, either common, Sect. 2. (as I said) to all Globes, or particular to this, and being well observed and remembred will much facilitate the ensuing Ope- Operations of rations, which are all naturally performed, either by the Sha- the Globe are dow of the Sun and Moon alone, or by the help of a small perform'd String, hanging fometimes from the Pin P, representing the with. North-Pole, sometimes from the Pin Z, representing (as I said) the Zenith, and garnisht with a little Bead and Plumet, according to its Figure in the Scheme aforesaid.

And here you are to take notice that tho the one end of the A Memoran-String be absolutely fastned to the Pole, to prevent the loofing dum. of it, yet 'twill ferve for the Zenith as commodiously as if it always hung from thence; for there is made at a convenient distance from the said fastned end, a little Noose or Ring, which (as occasion requires) is now to be over this Pin, and now over that; Nay if you give your String but half a turn about either of the Pins, you will (with a little Allowance) as exactly per-

form your Operation as if you used the said Noose it self.

To conclude, the whole Treatife is divided into fix Sections; How the The first folving several Questions that relate to the Sun in our Treatise is Elevation. The second, many Geographical ones, together divided. with fome that concern the Sun, not only where we live, but all the World over. The third is of the Moon; The 4th. of the Proportion of Perpendiculars to their shades, with some useful Corollaries thence arising; The 5th. of Dialling, and the 6th, of the Stars, id as ton sol (on I policio del sol of)

of the Gere; then there is to be under it a little wooden Raise, which being drawn out, and marke with a Star will force for

2. & 5. in

this and feveral other uses as you will fee anon. There is chother way speculatively true, the nerchance nearly exact in practice, which is thus performed. Place your

es malbirald and no goist of Bre with the Meridian as before - we if the Laterener or freeding of the Globe inft touches and dwars up showing as the Hommontal Circle, then

SECT. I.

Solving many questions, relating to the Sun in our Elevation.

Operation I.

To set the Globe level or parallel to the Horizon.

The fift way. T Begin here, because 'tis what we first suppose done in most Operations, especially in the nice ones, nor is the performance difficult, for we have nothing to do, but to place the String and Plumet exactly upon the South-fide of the Meridian or 12 a Clock bour Circle, and if it hangs just over the little Star on the Pedestal, then the Plane where the Globe stands is Horizontal and Level; otherwise 'tis faulty as much as the Plummet varies from being Perpendicular to the faid Star; for the Star (you must suppose) is engraved by the Globe-maker there, where he found the Plumet to hang upon his Placing the Globe truly level.

A: Memoran-

Let therefore the String and Plumer be always long enough to touch almost the Pedestal, for thereby you may better perceive any Error; and remember also that in case the said Pedestal (to be less cumbersom) be not as big as the Diameter of the Globe, then there is to be under it a little wooden Ruler. which being drawn out, and markt with a Star will ferve for this and feveral other uses as you will see anon.

The second may.

There is another way speculatively true, the perchance not so exact in practice, which is thus perform'd. Place your Globe on your Plane with the String lying on the Meridian as before, and if the Extuberancy or swelling of the Globe just touches and bears up the String at the Horizontal Circle, then

the Plane is Level, or Parallel to the Horizon, otherwise it differs as many degrees, as are between the point, where the

faid String touches the Globe, and its Horizon.

The reason of this is, That seeing the greatest and most extu The Reason berant Circle on a Globe is that which lies 90 degrees from its and Demon-Pole, the Horizon becomes here the greatest and most extube- fration of the rant one that can be described from the Zenith, therefore the Operation. Globe being on a Level which makes its Zenith to correspond with the Zenith in the Heavens, the String cannot fall short of the Horizon, because it must rest on the most extuberant Circle that occurs; nor can it touch below it, because the Plummet drawing the said String perpendicular from the greatest extuberancy, hinders its bending, and confequently its inclination to any part of the Globe beneath the Horizon. the Plane be not level, then the Zenith of the Globe and Heavens not corresponding, another Circle or part of the Globe, instead of the Horizon must have the greatest extuberancy and this Circle, being 90 Degrees from the point of the Globe, (which lies directly under our Zenith) it must differ from the Horizon of the Globe, as many Degrees as its Zenith differs. from that in the Heavens; therefore the way prescribed is at least speculatively true.

Operation II.

To find the Suns Almucantar, or Height.

Here are three distinct ways of performing this independent of the following Operations, and each of great use; for the first gives you the Sunsheight in an instant if he shines. The second if you have the least glimps of him, or can guess at his place in a Cloud. The third, if you know the hour by any good Watch, Pendulum or the like, whether we see the Heavens or no.

I. As for the first way, itis this; your Globe being level, The first way, move it till the shade of the Pin in the Zenith falls directly upon

B. 3

the Meridian, and then the shade of the Extuberancy (i.e. that made by the swelling or bellying out of the Globe) will touch the true degree in the Quadrant of Altitude reckoning from the Zenith to it. And thus you will find not only the Sun's height, fooner perchance than by any ordinary Quadrant, but will still have it before your eyes as long as you please, nothing being to be further done, but to move sometimes the Globe that the shade of the faid Pin may still concur with the Meridian. But if your Globe be fix'd, (or that for some particular reason, you have no mind to stir it at all, draw your string from the Zenith. through the shade of its Pin, i. e. lay the string in the Plane of the Sun, and then if you mount your Bead till it reaches the nearest part of the shade of Extuberancy, it will (by bringing it to the Meridian or Quadrant of Altitude) lye on the true Degree, reckoning (as before) from the Zenith to it.

The Reason and Domon-Stration of

How much the Sun illuminates more than half the Earth.

the term of the finade of Extuberancy when the su shines faint n ly.

The second Way.

The Reason of the Operation is this; The Sun when he rises brushes the Zenith and Nadir of the Globe with his Rayes, for he illuminates alwayes (within some few Minutes) just half of the operation. it, therefore when he gets (v. g.) a Degree higher, he must needs illuminate a Degree beyond the Zenith, and so proportionably from time to time, or else he would fensibly illuminate more or less of the Globe at one moment than at another, which Now fince the Sun in truth illuminates more than is abfurd. an Hemispere, the Reader must remember that Ptolomy reckons this excess (take one time with another) to be about 26 minutes, and Tycho something less, therefore substract 1 2 minutes (or half the said Excess) from what the shade of Extuberancy mark's, and you have his Height with all ordinary Exactness: but should you chance at any time to doubt how far the How to know said Shade of Extuberancy (which is not so discernable as that made by a Gnomon) just reaches, erect then a piece of stick, flraw, quill, &c. or, if you please, rest your Finger on the Globe, between the Sun and the point in dispute, and where the shade of your Finger, straw, stick or quill is lost, that will be The fecond if you have the leaband and i ome al entre le de le de

As for the Second why (for both the former we reckon but one) turn the Meridian of your Globe to the San as before, or because we suppose him not to shine out-right, direct by your Eye the said Meridian, fo that it lye in the same Plain with him, and this you may do in a manner as well (if you have the least glimps of him, or can by any accident guess whereabouts he is) as if you had the forementioned help of the Pin's shade in the Zenith. Having thus done, Take your String in both hands, and cross with it (as exactly as you can at right Angles) that part of the Meridian next your body, whether it happens to be the Quadrant of Altitude, or that of Proportion, then putting your Face close to it, and moving your Eye lower and lower, till by reason of the Extuberancy your can but just see the Sun, or his supposed Place in the Heavens, do but bring your String (held as before) to this Point, that is to say, do but bring your String towards you till it just takes away the Sun or his supposed station from your Eye, and the Degree in the Meridian on which it then lies, will be (counting from the Zenith) the Height required; for so far his Rayes would reach did he thinecourtright and Latter S) the thing principal of

The Third way is when we know the hour by any Watch, The Third Pendulum, &c. and 'tis thus perform'd; Find among the Aguinostial or Diurnal Parallels, that belonging to the prefent day, which we will suppose the 10th of April, and drawing your string from the Zenith, over that Point in the faid Parallel, where tis crost or cut by the hour given, i.e. by the morning 9 a Clock Circle, move up your Bead to the faid Point, and the distance from the Bead to the Horizon will be the required Height, viz. about 36 Degrees, as you'l find it, if you bring the Bead to the Meridian and count the Degrees between it and the Horizon is to said of cache of the miller of

The Sun's Height may be also known by his Azimuth, To know as which the V. Operation shews you how to finde. Having there, any time which the short of the eforeship Height 'mill some there it be fore by any of the aforesaid wayes his Height, 'twill (upon any Forencon or doubt) soon appear whither it be Fore-noon or After-noon, for Afternoon, as long as ever he increases in Degrees, i.e. mounts higher and higher above the Horizon, it wants of Noon, whereas if he falls and declines deisafter it salls side as minimal si ni solodi if you think better a Needle, in the Hole, which most agrees

with the true day of the Moneth, and then excoffen your Cale

ced; or, if it be not placed in any of the faid Paradele, maye the Globe till the made falls parallel to the next Dimant Parallel and "twill be, as train former'd as before, the period von bacen

level to the Sun, do but move it till the thade of the Areste noitaragor Fur fails directly along the Dimenal Paralle where its pla-

Operation III.

To Compose the Globe to the site of the World either by a Meridian Line or without it.

TF you have a Meridian line drawn, to wit, a Line lying ex*Op. 1. p.1g. 4. I actly North and South, place the Globe * level with its Meridian directly over it, that is to say, place so the little Noteh on
the Pedestal, (markt with the Letter S.) that it cover the
Southern Extremity of the said Line, and the Noteh N the Northern, and then the Poles and Circles in the Globe will (without
any sensible Error) correspond with those in the Heavens, and
each painted Region or Country on it, will be turn'd towards
the real one which it represents.

But if you have no line drawn, then know the day of the Moneth, and you have two expedite wayes to do this Operation,

without any foreign helps, which are as follows.

The first way to compose the Globe by the Sun.

The Globe having in it small pin-holes, on the several intersections of the Meridian with the above mentioned Diurnal Parallels, or (to be exacter) on each point of the Meridian which an imaginary Parallel of every fifth day would cut; for tho'we are to suppose Parallels for every day throughout the year, yet there being no sensible difference in the Sun from five dayes to five dayes, such holes will be abundantly sufficient; nay the aforesaid ones from ten Dayes to ten Dayes, may very well serve the turn in any ordinary Operation: I fay, the Globe having holes in its Meridian at this distance, put the Zenith Pin, or, if you think better a Needle, in the Hole, which most agrees with the true day of the Moneth, and then exposing your Globe level to the Sun, do but move it till the shade of the said Needle or Pin falls directly along the Diurnal Parallel where 'tis placed; or, if it be not placed in any of the faid Parallels, move the Globe till the shade falls parallel to the next Diurnal Parallel, and 'twill be as truly Compos'd as before, supposing you know

(as we have already * taught you) whether it be Forenoon or * Op.2.pag.6. Afternoon when you operate; for, as in the Morning the Stiles or Gnomons of Dials cast their shades Westwardly, and in the Afternoon Eastwardly, so must your Needle or Pin do, when the Globe is compos'd.

But here the Reader must take Notice, That in Case the A Memoran-shade of the Needle or Pin will by no means fall sensibly paral-dum. lel, but (as you move the Globe) draws nearer and nearer its being so, till at last it shortens to nothing, then the Sun is exactly South, and consequently your Globe is compos'd, as

foon as you find the shade thus vanish't.

The Reason of the Operation is this: The Parallel of the The reason or Day on the Globe can never concur, or be in the same Plane demonstrativith that of the Heavens, but when the Globe is Compos'd, that tion. is to say, when its Poles point directly to those of the World; for the Axis of the Globe and that of the World, being right Angles with the Planes of their respective Aquators, the Globes Aquator, if produc'd, will in stead of concurring, intersect with the other, in case their Poles disagree; but the Parallel of the Day on the Globe, concur's now and lies Directly in the same Plane, with that in the Heavens, seeing the shade of the Pin (which is ever in the Plane of the Sun) concurs with the said Diurnal Parallel on the Globe, and falls upon it, on the same side or quarter, as 'twould do, were the Globe plac'd on a Meridian Line, or truly composed any other way.

As for the second Way of Composing it, I shall defer it till the X. Operation, because the intermediate ones conduce much

to the facilitating of it: and fo let us go on where we left.

OPERATION IV.

To find the Day of the Month.

This Operation is also perform'd two ways, as being the Converse of the former, therefore since that requires the knowledge of the Day of the Month, this must require the Globe Compos'd. Having then compos'd it, by a Meridian Line, or any other way, you have nothing to do but to move the

10 The Description and use of the English Globe.

Pin from Hole to Hole, till it cast (as we mentioned before) a Parallel shade, or none at all; for then the Hole or Pin's place shews by the marks or Figures near it the Parallel, or day of the Month sought for.

The 2d. way. As for the second way you shall have it also when we come to the X. Operation, which treats (as we said) of the Second way of composing the Globe.

OPERATION V.

To find the Sun's Azimuth.

THE Sun's Azimuth, is an Arch of a great Circle which passeth over the Zenith through his body, so that his Morning's or Asternoon's distance (reckon'd by the Degrees of the Horizon) from the Meridian or Southern Cardinal section of the Globe, is the thing requir'd; and for performing the Operation, there are sour several wayes.

The 1st. way. First, * Compose your Globe, and draw your String from the *Op.3.pag.8 Zenith straight throu' the Shade of that Pin, and the Point which the said String cuts in the Horizon will be the Azimuth, reckoning the Degrees (as we said) from the Meridian to it: Demonstrati- for the String lying in that shade, lies in the Plane of the Sun, on. therefore where it cuts the Horizon, there will be the true A-

Zimuth.

Secondly, If you have only a Glimps of the Sun, or if you can but guess whereabouts he is by the brightness of the neighbouring Clouds, (as we mentioned in the II. * Operation) you may also perform this; for, if you guide your String by your Eye from the Zenith till it lies in the Plane of the Sun, or (if you see him not) in that of his supposed place in the Heavens, the Degree in the Horizon just under your String will (if the Globe be composed) be the true Azimuth.

Thirdly, Having taken the Sun's* height, and having found it to be, suppose 36 Degrees, bring the String to the Meridian, and by the help of the Degrees in the Quadrant of Altitude, Mount the Bead above the Horizon 36 Degrees, which Operation we shall frequently call hereafter, Restrigging your Bead to the

The 3d way.

the Sun's height. I say having taken the Suns height, and Rectifi'd your Bead to it, put your Ring or Noofe on the Zenith, and move your String, till your Bead lies exactly on the Parallel of the Day. Which we will alwayes in our Examples, or for the most part at least, suppose to be that of the 10th of April, and the said String will cut the Horizon at 58 Degrees Eastward (or thereabouts) for his then true Azimuth. And here you may re- A Memoranmember, That as the Height gives the Azimuth, so the Azimuth once known, gives the Height; for your string being on the true Azimuth, if you mount your Bead to the Parallel of the Day, it will show you in the Meridian the requir'd Height.

Fourthly, Supposing that on the 10th of April, the hourgi- The 4th way. ven be 9 in the Morning, draw your String from the Zenith over the Point where the Parallel of the Day, and the 9 a Clock hour-Circle intersect, and it will fall on the 58 Degree in the Horizon Eastwardly of the Meridian for the then Azimuth.

OPERATION VI.

To find the Sun's Declension, Parallel, and Place on the Globe at all times.

OY the Sun's Declenfion is meant, bis Northerly and South- The first way. erly distance from the Aquator, therefore if you know the day of the Moneth to be the 10th of April, you have his Parallel, because 'tis mark'd with the said day: Now since the Colurus Aquinoctiorum, or 6 a clock Hour Circle, is (as we faid) gradually divided from the Aquator to the Poles, and that the said Parallel passes almost throu' its 12th Degree, you have his Declension, as also his Place in his Parallel, if you have his Almucantar, or Azimuth as you will find by the fecond or following way.

If now you know not the day of the Moneth, Take the Sun's

* Almucantar and † Azimuth by some of the foregoing The 2. way.

wayes, and Restifying your Bead to the Height, draw your String *Op. 2. pag. 6.2 from the Zenith on the Herizon, according to the Azimuth TOP. 5. pag. 10

found; and your Bead will lie on his true Place, and confequently show his Declen sion and Parallel; for, as his Declenson is (as we said) his Distance from the Equator, so his Parallel is a Circle described from the Pole according to his Declination. And pray observe well this second Way; for the it be not extremely necessary in Relation to the Sun, yet it is of fingular use, when you come to the Moon and Stars, whose Declensions depend not on the day of the Moneth.

A Memorandum.

OPERATION VII.

To find the Sun's Bearing, i.e. in what part of the Heavens he lies, according to the Points of the Compaß.

TAving found by the foregoing Operation (on the 10th of April.) the Sun's true Place in his Parallel to be, suppose there where the 9 a Clock Hour Circle cuts it, lay over this Point your String, from the Zenith, and 'twill fall at the Horizon a little beyond the Character of S E b E for his Bearing according to the Points of the Compass.

OPERATION VIII.

To find when the Sun comes to true East or West, or any other Bearing.

TAving found the Parallel of the Day (viz. that of the 10th of April) and put your String over the Zenith, bring it straight to the East point, that is to say, to the point of the Globe where the Horizon and 6 a clock Circle interfect, and you will find the said String to cut the said Parallel about 20 minutes before 7 in the Morning, which is the exact time of the Sun's then coming to full East. Now if the String be laid on the Western Intersection, 'twill cut the said Parallel at 20 minutes or thereabouts after 5 in the Evening, for the time of the Sun's

coming to full West. In like manner, if you would know, when he come's (v.g.) to S.W. you are only to draw your String (as before) over that Bearing, and you will find by the Intersection of your said string and Parallel, that at a quarter past 2 of the Clock in the Afternoon, or thereabouts he will have that Bearing.

OPERATION IX.

To find what Signs and Degrees of it the Sun is in, at any time.

SEEK out the Parallel of the Day (viz. that of the 10th of April) and you will find it to cross the Ecliptic in two places, to wit at the first of Taurus, and the first of Leo; Now because in April the Sun is still Ascending, that is to say, the Dayes encrease, you may conclude that the first of Taurus is his then true place in the Ecliptick; for were he in Leo he would descend toward the Aquator, and consequently shorten the Dayes.

OPERATION X.

To find the hour of the Day by the Sun, together with a second way of composing the Globe, and finding the Globe, and finding the Day of the Moneth.

ANY are the wayes to perform this Operation as to the Hour, But now wee'l infift on four only, each of which has some peculiar Propriety belonging to it; for the First gives us the Hour by the help of the Natural Stile; the Second by an Artificial one; the Third without any Stile at all; and the Fourth (together with the said hour) the Contemplation of several pleasing Operations at a time, and among the rest this of Composing the Globe by the Shade.

1. Having * Compos'd your Globe, (and thus wee'l suppose it The 1st. way: in each of the following wayes) look among the Hour Circles *Op.3.pag.8. (which are, as we said, distinguish'd near the Polar Circles, with

little Roman Figures) and the shade of the North-Pole, or Axis of the World (which we may justly call the Natural Stile,) will, during the Sun's Northern Latitude, as well as the shade of the South Pole in his Southern, shew you the Hour. And thus you may find it for a while by the Ordinary Globes, in Circulo Horario, when they are once set or Compos'd, which I wonder none, of those who writ of their Uses take notice of; I say for a while, for it will only serve your Turn there from March to September.

The 2. way.

II. Your String hanging by one End on the North. Pole, hold it straight by the other, some little distance from the Globe, and moving it on the Noose, till its shade touch, or cover, the Apex of the South-Pole, 'twill show you (among the aforesaid Polar Roman Figures) the true Hour, even to a minute; for the Shadow of the String (which we call an Artificial Stile, because 'tis Independent and Forrein to the Globe) cutting at that Instant the Aquator, and Polar Circles, gives you in each place the Degrees of the hours, and consequently the minutes, since the 4th part of a Degree is an exact minute in time.

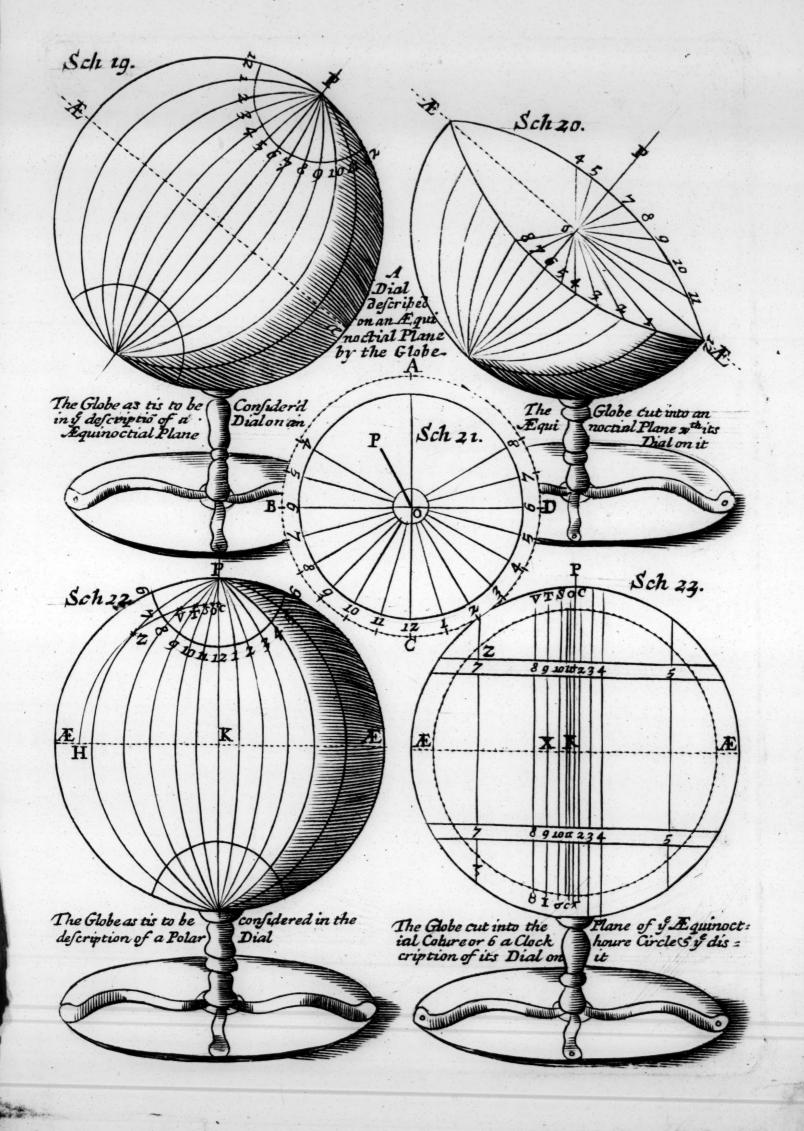
The 3d. way.

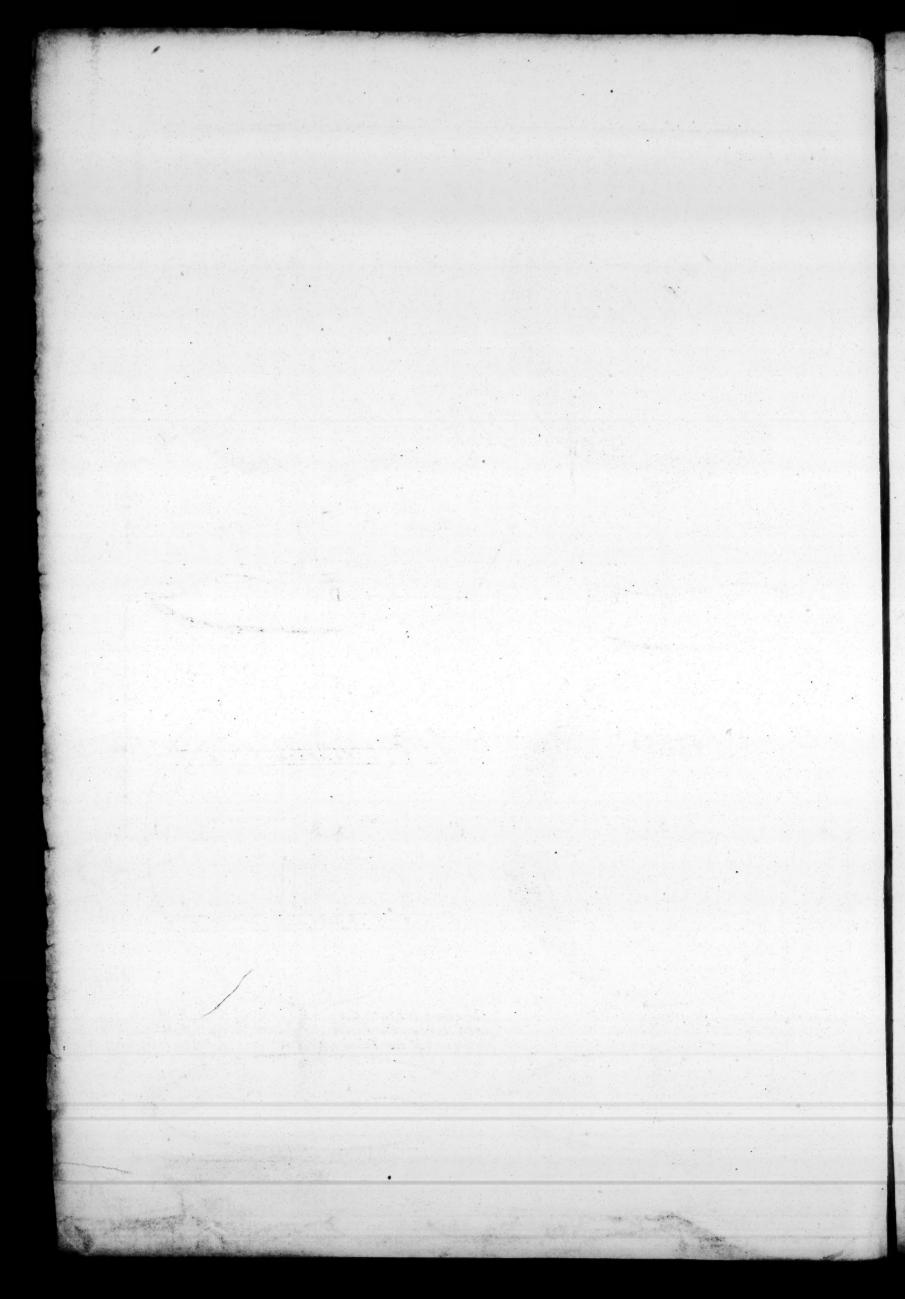
III. Look where the shade of Extuberancy cut's on the Anguator, and the great Roman Figures, (which are there for that purpose) will give you without a Stile or more adoe the exact hour, on what side soever of the Globe, you stand; for you must remember that the Extuberancy casts on the Agnator two shades, the one still Preceding or going before the Sun, and the other Following him. Now if this shade be dubious, your Finger (as I show'd you * before) will help you, it being the constant Remedy on all Occasions of this Nature.

* 2. pag. 6.

The 4th. way. As now you find the Hour by your String hanging on the Pole, so this Fourth way is to show it you, in case it had hung on the Zenith; nor have you more to do than to hold it by the end as before, and to move it on its Noose 'till its shade concurrs and agrees with that of the Pin in the Zenith, or for more Assurance till the Strings shade fall's so on the upper part of the Pillar or Fulcrum that it would cover the very Nadir, were it not hid, and then where the said String it self, or its shade cuts the Parallel of the Day, there will be the true hour, according to the Roman Figures of the Polar Circles.

con-





This way I would have you well observe for from hence I shall A Memoranhereafter lead you to the Contemplation (as I hinted before) of several pleasing and useful * Operations at one glance or view; and togive you a little Tafte at present, I will here shew the conclusion you the Second way of Composing the Globe by the shade.

Having for Expedition's sake, turned the North-pole of the ter. Globe, as near as you can guess to that of the World, Hold up your String with one hand to the Sun in the manner now pre- the Globe by scribed; That is to say, 'till the String hanging from the Ze- the Bade. nith) casts its shade on the Nadir, then move the Globe with your other hand, and making by a proportionable motion of the String its shade to pass still throu' the said two points, observe when it cuts the Parallel of the day at the like hour with that, which the shade of the illuminated Pole indicates, and your Globe will be composed; or, to express this in fewer words, Move thus the Globe, till the shade of the string and the shade of the illuminated Pole agree in the Hour. Nay fixing your String in the Zenith as before, and fastning a Thred on the North-pole, do but hold up both to the San till the shade of the String passes. the Nadir, and that of the Thred the South Pole, if any body then moves your Glabe about till the two shades (passing still : throu' the foresaid Points) intersect on the Parallel of the Day, you have your intent; for the Sun being you see in the Planes of Demonstratithe Thred and String he must be in their Intersection. i.e. in the on. Parallel of the Day; but is impossible for him (as we * show'd * 09.3. pag. 8 you) to be in the plane of that Parallel, on the true fide of the Meridian, except the Globe be Compos'd, for the corresponding Circles of the Globe and Heavens can never else agree; therefore the Operation is true; and if so, let the Globe be but on a The 3d. way Meridian Line, or any way elfe Compos d, and the Agreement of finding the of the hour in both places or the Intersection of these two shades day of the thews the Sun's Parallel and confequently the Day of the moneth.

So much then for this second way of composing the Globe, and finding the Day of the Month, which first came into my thoughts by reflecting on the Projection of that great man Mr. Oughtred, who would have bin the Wonder of this Age, had he bin as ambitious and forward, as he was throughly learned.

Charles of the part where I was a few to the country

particulars in or last Chap-

The 2d. way

OPERATION XI.

To find the Hour of the Day when the Sun shines not.

MOp.2. pag.6
& Op.5. pag.

O perform this Operation, we must suppose you know either the Suns Almucantar, Azimuth or Bearing; and by the way you may find these, tho he * shine's not; I say you must suppose either his Almucantar, Azimuth, or Bearing, for they giving you his Place in his Parallel, the next Hour Cirrele to his said place shews you the time of the Day; for if (v.g.) in the forenoon on the 10th of April.) you know that the Sun is 36 degrees high, Rectify your Bead but to that height, and moving the String from the Zenith your said Bead will touch the Parallel of the Day at 9 of the Clock. In like manner if you know the morning Azimuth to be suppose, 58 degrees, draw your String from the Zenith over the said Degrees in the Horizon, and 'twill also cut the Parallel of the day at 9. Or, if the Sun's Bearing be (for Example) a little more than S E b E the laying of your String from the Zenith on that Character in the Horizon shows you on the Parallel of the day that 'tis 9 as before.

OPERATION XIL

To know when the Sun rises and sets.

IND the Parallel of the Day (to wit that of the 10th of April) and where it cuts the Horizon on the East-side of the Globe, there the Suns place at his Rising will be so that the time of the day appears by the next Hour Circle to be a very little past 5 in the morning; and if you cast your eye in the Intersection of the said Circle on the West, you'l find the hour to be almost 7 in the Evening.

To find when, This being so, here sollow's a very pleasant and useful Operaand at what tion, as a Corallary, viz. How to find at what time of the year, declension, the and at what Declension the Sun rises or sets, an Hour, or any sun rises or other space of time, either early or later, than it does at the prolater, accord-posing of the Question: for, if you observe but what Parallel intersects fests with the Horizon, on the 4 a Clock morning hour-circle which is an hour earlier than when it rises on the 10. of April, you will si dit an Imaginary Parallel, which the next real or mark't one shews to be the Parallel, for the 14. of May and 12. of Inly, and consequently by the Devisions of the Aguinosti-al Colure that the then Declension is about 21 Degrees. In like manner you must have look't on the West side of the Globe if you would have had the time of the Sun's setting an hour later than 7; and thus you are still to operate when any other space of time is required.

OPERATION XIII.

To find the Sun's Amplitude, Ortive or Occasive.

BY the Sun's Amplitude we mean his distance in the Horizon from the true East and West Points at his Rising or Setting; so that this Operation is also a Corollary from the former; for, knowing (on the said 10. of April) the point or place where he Rises, you will find the Ortive Amplitude to be Northward from East about 18 Degrees, and (on the other side of the Globe) the Occasive Amplitude, to be Northward as much from the West.

OPERATION XIV.

To find the length of the Day and Night.

Donble the hour of the Sun's Setting, (which on the 10. of April happens, as we said, about 7 at night) and the Product (to wit near 14 hours) will be the length of the Day; or double (5) the hour of his Rising, and the Product (10 hours) gives the length of the Night. Nay, if you do but consider how the Parallel of the Day is cut by the Horizon, you have the whole business represented to the life at one view, even as it happens in the very Heavens themselves; sor that part of the said Parallel above the Horizon, being devided to your hand by the Hour-circles, into almost 14 hours, shews the Days length, and consequently that part under the Horizon (shewing a little more than 10 hours,) gives the length of the Night.

OPERATION XV.

To find the beginning and end of the Crepusculum.

BY the Crepesculum is understood the Twilight which appears before the Sun's Rifing, and continues after his Setting; for as foon as the Sun comes within 18 Degrees of the Ho. rizon (according to the Opinion of the antient Astronomers) or within 16. Deg. according to that of Tycho, and some Modern ones) his Rays are reflected from the Atmosphere or circumambient vapours, and confequently illuminates, so that this light still encreases, by how much the Sun approaches the faid Horizon, and decreases as it recedes. Now to find it, you are to bring the String hanging on the Zenith to the Meridian, and making the Bead (if you follow the latter Hypothesis) to stand by the help of the Quadrant of Depression) at 16 Degrees under the Horizon, move it on the East side of the Globe along the Parallel of the Day (i. e. that of the 10. of April) till it just touches the faid Parallel, under the Horizon, and there will be the true point of the Morning Crepusculum, which the adjacent Hour-circle tells you begins about 3 in the morning; In like manner if you move your Bead on the West or Eveningside of the Globe, you will find it to end neer 9.

OPERATION XVI.

To find the Sun's Depression at any time of the Night.

bed happens, as we

BY Depression we mean, how many Degrees the San is then under the Horizon, which is easily personned if you know the hour of the night, by the Moon, Stars, Clock, or the like, for, finding (as hath been * shown you) what part or point of his Parallel the Sun is then in; i.e. where the Hour-Cincle (corresponding to the time of the night) and Parallel of the Day interfect, draw the String from the Zenith over it, and moving your Bead to it, bring the said Read to the Merid.or Quadr. of Depression, and then by the help of the Degrees there (reckoning

*Op. 6. pag.

* Vid. Oper. 13. Sect. 2.

from the Hirizon to the Bead) you have before you the required Depression.

OPERATION XVII.

To find the Sun's Right Ascension.

THE Right Ascension is that Point or Degree of the Aquator cut by the Meridian, or Hour Circle that runs through the Sun's place in the Ecliptic; and this Degree is called the Right Ascension, because in the Position termed by Astronomers and Geographers the Right Sphere, (which together with the Oblique and Parallel Spheres, shall be farther explained in the Geo-

graphical Section) it rises or Ascends with the Sun.

To find then the Sun's Right Ascension (a thing often of great Use) you are only to take the String (hanging from the Pole) and lay it on the Degree of the Ecliptic possess then by the San, that is to say upon the 1st. of & (for the 10. of April is still our Example) and the Degree of the Equator cut by the said String is the required Right Ascension, which counting from γ or East Point (as you must always do) happens to be 28 Degrees, or thereabouts.

OPERATION XVIII.

To find the Ascensional Difference.

A Sfor the Ascensional Difference (i.e. the Difference between the Right and Oblique Ascensions) we have it here before our Eyes at a View, as being that portion of the Day's Parallel which lyes between the Sun's Rising or Setting, and the 6 a Clock Hour Circle, so that if he rises on the 10. of April at almost 5. and sets near 7. we may conclude that the Ascensional Difference is about 14. Degrees, for 15. make an hour. But if you will be exact, then lay the String from the Pole on the Point where the Sun rises or sets, and when it cuts the Aquator, count there the Degrees from the said String to the 6-a Clock Circle, and all is done. Thus then you see, that when we

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know

know the Ascensional Difference we have the time of the Suns Rising and Setting, for it is but adding it to 6 a Clock, if the Sun be in his Northern Declension, or substracting it in his Southern.

The END of the first Section.

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SECT. II.

Of the Operations that concern Geography.

Preliminary Considerations Aving given you a short account of the Operations immediately relating to the Sun, without reflecting upon any part of the Earth, but that, on which we then stand, weel now descend to those that concern Geography, where you may have a view not only of all Countries, as to their Situations, Extent and the like, but see at one glance when you please, several other things appertaining to them worth the knowing; as, What a Clock it is in any place imaginable; what People are Rising, who are going to Bed, and who to Dinner: as also, where it is they have no Night, where no Day, with divers particulars of the same nature, which were thought by many sormerly not performable without Magic.

That our Instrument is Geographical, no body will (I dare say) doubt, it being the Terrestrial Globe, and consequently the Epitome of the very Earth it self; and besides its many other Operations) it may be perchance useful in this, that all Countries are here more obvious, and consequently more easily sound out than in any common Universal Map or Globe. Nor do's it a little contribute to it, and fix the Position and Order of the said Countries in our Memory, that not only the Divisions and Subdivisions of the Earth are (by our present Directions) clear and distinct, as sar as this small bulk can afford, but freed also from the usual crowd of Towns and Places, very often neither of Note nor Use, unless for Distraction. For

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the business of a Terrestrial Globe, is to represent the situation of samous Regions and Provinces, and how they are distant each from the other; to show us also where the late Discoveries are; where more may chanceto be made; what proportion any Place bears to the known Parts, or they to the whole Terraqueous Mass. These (I say) and the like, are what a Globe is properly to represent; for small and inconsiderable Places ought not to be there, as being the chief Object of Chorographical and Topographical Charts, to which the curious are to recur upon occasion.

As for the first or grand Devision of this Globe, to wit, the sour The grand Di-Quarters, their names are in the midst of them in re-visions of the markable Capital Letters; nor is there any trouble about their Earth.

Bounds, after that that joyns Europe and Asia is consider'd, for bating the little Isthmus made by the Mediterranean and Marerubrum (which contains the limits of Asia and Africa) there is no part of the said Quarters, which is not surrounded by the Sea. For the separation then or Boundary between Europe and Asia, it is a fine black line, that beginning at The Boundathe mouth of the Tanais, runs up the Stream to Tuia (situated to between on its most Easterly Fiexure,) and thence going to the rearest Europ and Asia.

Banks of the River Oby, accompanies it till it falls into the Northern Ocean. This I say is the separation drawn by me, and not from Tuia to the mouth of Duina at Arch-angel; for since there are (as to the Question in hand) different and

various Opinions among Geographers, I follow the rather this Devision than any other, fince it contains almost all the vast Dominions of the Russian Emperor, and so makes him as it

were an intire European Monarc.

The Devision of each modern Country from the other (which The Division have all their Names on them in small Capital Letters) is also of each mode a black pric't line, and that you may have a glimps aldern Country so of Antient Geography, I have exprest some of the from the other most considerable old Nations and Empires; by Prick Lines of The Ancient several colours (as the directions on the Globe it selfshews you) Limits of seto amplify or contract their Bounds; when they agree not with veral Nations. the present Limits; but as for Cities and Towns, there are (as I said) but very sew of any sort set down, for in all the Island of Great Britain, we mention but London and Edinburgh; befores a Port or two, in which proportion we proceed all along.

Thus

Thus having acquainted you with these sew Preliminaries, wee'l now, after you have a little consider d the Names of each Country, and how they all lye from your Zenith, where you are ever to suppose the Country or Place to be, which the Globe is made for; I say, we will now, after you have a little considered these things, sail upon the Operations, an Employment commonly much more diverting and pleasant than Speculation.

OPERATION I.

How to find the Distance between any two places.

IF the Question be (for Example) between Constantinople, and the Place you dwell at, (which we shall for the Future suppose still to be at London) Draw your String from the Zenith streight over Constantinople, and having mounted your Bead thither, bring it to the Meridian, or Quadrant of Altitude, and it will lye (counting from the Zenith to it) on the 24 Degree, cr thereabouts, which multiply by 60 (the number of Miles contained according to the Common Account in each Degree) shews you that the Distance required is some 1440 Miles. But if it be demanded how far it is from Constantinople to Tangier, i.e. from any other two Places, when reither lye under your Zenith, then take a pair of Compasses, and placing one Foot on the first Town, and the other Foot on the second, find (in the Meridian, Aguator, Horizon, or any other divided great Circle) the Number of Degrees between the Feet, which making about 31. amounts to near 1860 miles. Or it you have no Compasses, fix the loose or Phummet end of your String with your Finger on Tangier, and drawing the rest of it streight over Constantinople, place there the Bead; and if you measure that distance in any of the said devided Circles twill give you theabove mentioned Degrees and Miles.

A Table of reducing D:grees into Miles.

And here be pleased to remember that to free you from Multiplication in Relation to Miles, I have ordered a little Table to be plact in the vacant part of the Globe towards the Southern Ocean, where you may find from 1. Degree to 20. how many Miles any number of Degrees give; but if your Cuestion con-

or two, in which proportion we proceed

tains

tains more Degrees than are set down, as for Example 31. you are only to add 660. (which you will see in the Table is the vallue of 11. Degrees) to 1200 (the value of 20.) and the Sum Total makes 1860. Miles for the required distance. In this manner you must operate in other cases.

The Table of Reduction is to be in the following manner.

40-117	60	563 70	11		660
2	120	TESTE NEW	12		720
3	180		12		780
4	240	1:07			840
\$1.0000)	300	outd ha	15		900
6	360	ic practs	16	Y 6	960
7	420	Mary Mary	And the second s	The state of the s	1010
8	480		18		1080
9	540	6 6 96 1	19		1140
10	600	10,200	20		1200

for all of the II. I mages at Tomeroff it and many other OPERATION II.

Vor is there lets do about the Caramar, for the France fix it at

How to find the Latitude and Longitude of any Place.

He Latitude of a Place is its nearest distance from the Equator; If therefore you would know the Latitude of, (suppose) Constantinople, draw the String from the Pole over the bon to find it faid City, and placing thereon the Bead, bring it to the gradual devision of the Colurus Aquinottiorum, or 6 a clock Hour Circle, and it will lye on the 42 Degrees, and about 5 minutes, more, for the Latitude required.

What the La-

titude of a

The Longitude of a Place is the number of Degrees (reckon'd What the Lon-Eastwardly in the Equator) from the grand Meridian to the situde n. Hour Circle, or particular Meridian that passes through the Placerequired.

As for the faid Grand or General Meridian, 'tis that from Of the Grand! whence we begin our Reckoning; and fince it matters not (as Meridian. you will plainly see in the Memorandum of the third or following Operation) where we commence, to wit whether from the

Meridian that runs thro' London, or that thro' Paris, Rome or any other place, if people be acquainted with it before hand; I fay, fince this is fo, what wonder is it, (there being by reason of some accidental Proprieties and Causes infinit fit Places) if Geographers and other Learned men quarrel in the Affair, and earneitly strive to have the Prerogative granted that Countrey, which they are pleased to propose.

Of the most noted Places where Auchor's have plac't the grand Meridian.

Of all places, the Hesperides, Azores and Canaries, (by reafon of their Westerly Site, or the pretended non-variation of the Needle in some of them) have had the most vogue; but fince each of the said Places make not one but many Isles, they afforded new occasion of Dispute; for among the Hesperides, or Istes of Cape Verd, some would have Fuego to carry away the Bell, some St. Nicholas, but others St. Vincent, as appears by Hondin's Globe. Now Langrenius, in his, begins from St. Mary and St. Michael in the Azores; fobr sonius in his Univerfal Map, counts from Corvo and Flores, whereas the Learned Dudley (the late Titular Duke of Northumberland) gives the honour to Pico, and has as much reason for it as the rest. Nor is there less do about the Canaries, for the French fix it at Ferro, several of the Hollanders at Teneriffa, and many other Nations at Palma, which is the Place I would willingly choose, (since the great Ptolomy thought fit at last to assign it there) were it as convenient for my present purpose as St. Vincent.

Where me fix our Grand Meridian.

'Tis St. Vincent then I here pitch upon for this Meridian to pase throu', because it differs in Longitude from London within less than 20 Minutes of just 30 Degrees, or 2 Hours, so that the 2 a Clock Circle will represent it (within almost a Minute in time) without need of drawing a Particular one, and the faid Meridian is (as I told you in the beginning) distinguished from the rest by Pricks, which being diffant from each other a quarter of a Degree, are useful on several occasions.

How to find of any place.

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Having thus fixt our Grand Meridian, or first Longitude, the Longitude that of other Places follow's with ease; for if you would know the Longitude of Constantinople, draw but your String from the Pole over it, and it will cut the Aquator neer the 62. Degree for the Longitude required, as you may readily percieve by the lower little Aquinoctial Figures.

ec in the Memerandres of the chief or follow

OPERATION III.

How to find out any Place, the Longitude and Latitude being given.

His Operation is not only usefull for the finding out of Towns express'd on the Globe, when you cannot guess whereabout they are fituated, but also for the placing them truly in case they should chance not to be set down. Suppose then Constantinople were the Town sought for, and that you found its Latitude to be 43 8. 5'. and Longitude 61 8. 46'. in some book or Geographical Table; I say supposing this, you have nothing to do, after having mounted your Bead (by the help of the devided Colurus) 43 g. 5'. above the Aquator, but to move your String on its Noofe from the Pole to 61. 46. in the faid Equator, and Constantinople will be just under your Bead; and if (in case of Omission) it should not, you may then if you please marke it out your self, for that is its exact place.

But by the way, if the Geographical Tables agree not with A Memoranthe Longitude of your Globe as telling you that (v.g.) Constan- dum: tinople has but 54 8. 36, you are then to look from whence the said Tables begin, and finding their Commencement, suppose at Palma, and that Palma (according to the former Operation) has by your Globe 7 8. 10'. of Longitude, you must add this num-

ber to your Tables, and then you will agree.

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on call abytes OPERATION OF TRANSPORTED TO had out the very Clime if leth.

To find the situation of any Place according to the Angle of Position, or Points of the Compass.

Raw the String from the Zenith over, v.g. Constantinople, and 'twill cut the Horizon about & Degrees beyond Eb S Eastward, for the true situation of the said Town from your Habitation, according to the Points of the Compais.

OPERATION. V.

To find in what Clime or Parallel any Place lies.

Climes.

A prelimina. D Efore we can here well come to Operation, there are some ry Discourse of D sew Particulars to be consider'd; and first what a Clime is; which is no hard thing to conceive, fince most know that after the Vernal Equinox our Days not only exceed 12 houres, but that every neerer Countrey to the Pole has days of greater Length than the Remoter: Nor are there many ignorant, that when our Days (that live on this fide of the Line) increase, theirs on the other side decrease proportionably, and when theirs encrease ours decrease; so that no People are at a Constancy, but they that dwell exactly between both Poles. to wit under the Equator. This Diversity was thought by the Ancients a thing fo fit to be known, that they invented the Devision of the Earth into Climes, so that as soon they heard a Countrey named, they prefently (besides the fond Reflections concerning the Temperament of the Air, Ingeniety of men, &c.) knew the length of its longest Day, and consequently how much any other Place exceeded or came short of that length.

> For suppose the first Northern-Clime were to pass over all the Places on this fide of the Aquator, whose longest Day is 12 hours and 1; and the fecond Clime those of 13 hours, and so on towards the Pole by a half hourly Increment, what difficulty could there be to resolve immediately the Question, when we once know the Ctime, or having the length of the longest Day to

find out the very Clime it felf.

I Wonder therefore, that so ingenious a man as Bleau, should seem to assert, that this Devision is useless, it being as easy to find the longest Day as the Clime; whereas, were Climes in esteem and fashion, the Memory would as soon conceive and remember in which of them any Countrey lay, as now redoes it's Bounds, the manner of its fituation, and the like; and if fo, one may quickly judge whether they are ufeless, and whether it be possible that the length aforesaid can be known by any other means so universally, and at so easy a rate.

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A Clime then (generally speaking) is a space contained be what a Clime tween two Circles Parallel to the Aquator, having the Places ". thro' which they pass differing (as to the length of their longest Days) half an hour; and this space takes the name of Clime from Kniver Inclinare vel Deflectere; for the greater our Deflettion is from the Equator or Right Sphere, the longer our Summer Solstitial Day will be. Nor were the Antients content with this large Devision of the Earth, but subdevided it into Parallels, so that Places differing a quarter of an Hour, were reckon'd to be under such and such Parallels, which some call Artificial (from their relation to the Artificial Day) to distinguish them from all others that occur.

As for the Antiquity of Climes, 'tis immemorial; nor could Of the Antithere be many in the beginning by reason of the small extent quity and of the known parts of the World; For the Ptolemy reckons a- number of bout 10, that is to fay 21 Parallels, as making them to reach as Climes. far as Thule; yet Homer, Ovid and other Poets, so posses'd men with the Fancy, that from the Cimerians Northward, there was nothing by reason of the hideous vapours and exhalations, but a dubious and creperous light, that even Pliny, and after him the Arabians infifted only on feven, looking on all Countries that lay farther as not worth perchance the taking no-

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As for the seven in vogue with them, and mention'd also very Of the 7 comparticularly by our Countryman Sacro-bojco (whose credit mon Northern and great Repute has perchance not a little kept up their Fame Climes. among the Moderns) they were, Dia-Meroes, Dia-Syenes, Dia-Alexandria, Dia-Rhodou, Dia-Romes, Dia-Boriftheneos, and Dia-Riphoeon, being all names made by the Addition of the Greek Preposition fia (i.e. per) to some remarkable Town, River, or Place, thro' which the middle of each Clime past; so that the middle of the first went thro' Merce, an &thiopian City on the Nile, where (according to some) Queen Candace Reigned; the second thro' Syene in Egypt, lying just under the Tropic, the third thro' Alexandria; the fourth thro' the Ise of Rhodes; the fifth thro' Rome; the fixth thro' the mouth of Boristbenes, now called Nieper by the Cossacks and the other Inhabitants; and the seventh and last thro' the Riphan Hills, part of which lay according to their account in

or about, the Latitude of 50 Degrees, and consequently cor-

responded with the Cimerians.

Of the 7 Southern Climes. Twas here then that Alfraganus and other Arabians ended Northwards, who besides several smal particulars, err'd not a little in making Rome and the Boristhenes only a Clime asunder, when as their longest days differ at least an hour. And as for the Southern Climes (to wit those on the other side of the Aquinoctial) they thought sit to consider them, but not knowing what to call them, as being ignorant (for the most part) of the Places they went through, they added 'Arri (i.e. Contra) to the former Denominations, so that making Antidia Meroes serve for the first Clime, Anti-dia Sienes for the second, they proceeded in the same order with the Rest.

why the middle of the first Clime has 13. hours of day.

But now before I end, I shall endeavour to folve a difficultywhich startles not a few, viz. howit comes to pass (seeing the Climes are affigned (as we mentioned) by the Antients, to know the length of the Summer Solstitial day in every Country) that the middle of the first Clime (which in rigour should lye no further from the Equator, than to encrease the day a quarter of an hour) runs over Meroe, where the Excess is at least an hour. I answer, the Antients, deeming it more equal that the middle of the Clime, and not the end of it should be the Point where the half hourly increment was to begin, fixt the Terme à quo, not in the Equator; but a quarter of an hour further, and therefore Taprobane (which some now think Sumatru) was the place where Ptolemy commences all his Climes, making thereby the middle of his first to pass per Sinum Avalitum or (Mouth of the Red Sea) and the middle of his second per Meroen: But the Arabians, thinking that for several Degrees from the Aquator all was either Sea, or (by reason of the Heats) scarce Habitable, or else judging it for their Honour, to have their own Country in the first Clime, began half an hour beyond The probane, and so Dia Meroes, (the the Days are there 12 hours long) leads the Van in their Catalogue.

How the first circle of Longitude is divided as to the Climes.

These sew things premis'd, I shall now shew you the way I take therein, which I think in all respects clear and ready. First, I make the primary Circle of Longitude to be the Circle particularly appropriated to this use, being devided and mark't according to the true distance of each Clime from the other; and as to the place where they commence on our Globe, I rather.

fola-

follow Prolomies Astronomical than Geographical Method; for (besides the aforementioned excess of the Arabians) should we begin but a quarter of an hour from the Equator, it makes a great space of the Earth, viz. from Taprobane to the Equator, to be in no Clime at all; and which is more, it causes a little confusion, when the length of the day is greater in every Clime, than what the faid Clime can justly challenge, according to its Rank and Number; I fay, as for the place where the Climes commence, I rather follow Ptolomies Astronomical than Geographical way; and therefore beginning at the very Equator, my first Parallel (or middle of my first (lime) is supposed to run over the places that enjoy 12. hours and a quarter of Day, and the end of it (noted on the primary Circle of Longitude or 2 a ClockHour Circle with the Figure 1. Jover the places that have 1.2. and 1; and thus we proceed to the Polar Circles, to wit, where the 24th. Clime, or 48th. Parallel terminates, so that from thence we come to the Devisions on the faid Circle of Longitude, which flow where the days are as long as an ordinary Week, where as long as a Month, and where as two, arriving at last at the Poles themselves, where there is a constant balf year of light, and as much of Darkness. And to give you a Remembrance of the Names of the aforesaid old Climes, and that you may also see without Calculation or Trouble where the Ancients plac'd them, Thave fet down the first Syllable of their names (as Mer. Sy. Al. &c.) according to their respective Latitudes.

To find then in what Clime any place is (v. g. Constantinople) To find in you are only to draw your String from the Pole over that City, any Placelies. and mounting up the Bead thither, to move it to the faid Primary Circle of Longitude, and twill lye on the Clime or Paralel required. But if you would know what places are (suppose) under the 4th. Clime, throu'out the World, i. e. what places have their longest day just 14. hours; Fix the Bead on the 4th. Clime and moving it on its Noofe from the Pole round the Globe, you may conclude that every place it passes over, has the Sun exactly so long above the Horizan, when the days are at the longest: and in the same manner you must proceed on the South of the Equator, to find the Country's that lye under the 4th. Southern Clime. In short, here we have, besides (what has been already Of the inefaid) a view not onely of the strange inequality of the Climes, quality of the (especially between the first and last) but also of their exact di-

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stance in Degrees, and consequently in Miles, by help of our Table of Reduction, mentioned in the first * Operation of this pag. 23. Section.

Of the 5 Zones.

But seeing we are a little fallen into Speculation, 'twill not be, perchance, improper to proceed yet further, and to confider here, as in a natural and fit place the Bounds and Terms of the five Zones, so called from Zovn Cingulum, as enclosing the whole

Zone, which contains the Amphiscii,

of the bounds World within their respective Districts: 'Tis with the Torrid of the Torred one we'l then begin, whole Bounds are the two Tropics, so that the Diurnal Parallels not only remarkably distinguish it from the other Zones, but shew why the several Inhabitants within this space were called by the Ancients AMPHISCII, i.e. Utrinque umbrati, or men that had two shadows, from 'Auge utrinque & Inia Umbra; nay, by the said Parallels you may find when the shade will change and be different; For, since by these Paths or Traces the Sun (as we often hinted) passes from Tropic to Tropic, 'tis evident that fometimes he must be on the Northside and sometimes on the Southside, of all that live here, which must then needs alter the shadow. And as for knowing the time of this change, we are only to confult the days of the

To find when the shade changes side bere.

Month on each Parallel for that which passes over the Heads of the propos'd Inhabitants, shews that from that time to the 11. of fune (or the Sun's coming to Cancer) and so till he comes again to be Vertical, their shade will be full South at noon: whereas from his said Vertical Ration to the 11. of December (when that he enters into Capricorn) and so till he comes again to them. their shadow will be directly North.

Of the frozen Zones which contain the Perifcii.

To front in

From this Torrid and hot Residence; we'l now run to the obounds of the ther Extream, viz. to the two Frozen Zones, which lying from each Polar Circle to the very Poles themselves, are sufficiently diffinguish'd from the rest.

Now fince the longest day within these Limits is at least 24. hours in length (as we show'd you even now in treating of the Climes) and fince the Sun in this space of time, compasses the World, it must follow that here he runs round the Inhabitants, which gave the name of PERISCII to them, that is to fay Circum Umbrati, or surrounded with their shadow, from

Of the

bounds of the de Circum & (xia Umbra,
Temperate As for the two remaining Zones, they are the Temperate ones, bounded by the Tropic's and Polar Circles: Nor do the Incontain the Heteroscij. haoitants 92711.

Prominent

habitants of this moderate and more excellent polition want an appellation from the property of their shadow also; for never having the Sun but on one side of them (as still setting before he gets round) and unable to pass, as he could in the Torrid Zone over their Heads, by reason he has no excursion beyond the Tropics) it must needs follow that their shade who live in the Northern Zone, will ever fall North, and theirs in the Santhern, South; fo that they were called HETEROSCII, i. e. Habentes alteram folum Umbram, or People having but one kind of shadow, from Fresh alter & Cula Umbra.

So much then for the Climes and Zones, together with their various inhabitants, and now we will proceed to the Operations ways to perform this Operation, but feeing the wolld

most clear and expedire, I telely inflit on

OPERATION VI.

To know what a Clock 'tis at any time, in any place of the World noise dill so poilleve

The first is that, which lies opposite to you in

Here is no Operation perchance in the whole Treatife, First way. I more diverting and pleasant than this; nor scarce any more readily perform'd after a very little Reflection, even in the most disficult Cases. For having Compos'd your Globe, if it be then 12. a Clock with you, the standing Honn Giroles or Men ridians already deferibed, will (by the Common or little Figures which lye within or upon the Roman ones, that furround the Palar Circles,) they you exactly the Hour, whereforever you cast your Eye; That is to fay, that trisabout 2 of the Clock at Con-Stantinople, 3 at Aleppe, &c. But now, Tit be not 12. with you but (v.g.) 3 in the afternoon, when you defire too know the then hour at Constantinople, add the said 3 a Clock to the Biguire 2. (which you fee lyes, as I now mention'd on the Meridian or Hour - Circle, that runs near that City) and twill tell you that tis about s a Clock there mand thus you materalways do, unless the time of the Day with you, and the Figure that lies on the Meridian of the place in question make a greater number than 12; for then the Hour fought for, is what remains above 12; as for Example, if it be 11 with you, then this with 2, (i.e. the Figure near the Meridian of Constantinople) making

13, do but cast away 12, and you may conclude it there 1 in the Asternoon.

There are several other ways of performing this Operation:

Second way.

Third way.

as finding the Difference of Longitude between you and the Place in Dispute, and so adding or substracting it (as need requires) from the true time of the Day, Or else by calling it always Mid day, there where the Hour Circle that shews your then true time of the Day (which by our Example is 3 in the Asternoon) crosses, for by counting from thence to the Meridian of the Place in question, either sorwards or backwards (as 1,2,3,4, or 11,10,9,8, Gr.) according as the said Place lies East or West from 3, and all is done; I say there are several ways to perform this Operation, but seeing the first is the most clear and expedite, I solely insist on it: and now because you may be perchange running over with your Eye, the whole Globe, and considering how one Situation or Country differs from another in time, 'twill not be amiss to tell you that

there are 3 Places, that have more particular Relation to your

Dwelling or Habitation than any other.

Of the Peria-

The first is that, which lies opposite to you in your own Parallel, whose Inhabitants are called by the Antients PERIACI, or Circumcola, from Sec Circum & onio habito, and though by the Word, all People are comprehended that dwell any where in the said Parallel, yet Geographers commonly mean those by it, that are thus Diametrically situated. These then live in the same Zone and in the same Clime, and cast the same kind of Shade with you: These enjoy your proportion of Heat and Cold, your Seasons of the Year, your Encrease of Days and Nights, and in short all things else of this kind, saving that your Hours are opposite; their six in the Evening being your six in the Morning; and your Noon their Midnight of the same Morning; and your Noon their Midnight of the same Morning; and your Noon their Midnight of the same Morning; and your Noon their

Of the Anta-

The Second Place lyes under your very Meridian, or 12 a Clock Hour Circle, which makes your Hours and theirs the same, but by being 51 830. on the other side of the Aquator, it happens that the you all agree in the Temperament of your Zones, number of Climes, in the Casting a Shadow on one side onely, and the like, yet their Zone and Clime are Southern, their Shade salls toward that Pole, their Summer is your Winser; and your Spring their Annum, so that from this contrariety

trariety they are named ANT-ECI or Adversicola from ari

contra & oune Habito.

The Last is the Nadir or Point on which the Globe Stands, whose Inhabitants are called ANTIPODES. i.e. opposita habentes vestigia, or menthat walk Feet to Feet with you, from 'Avn Contra, & Hoses Pedes. These imply (even by the vulgar acception of the word) the height of Opposition; and fince they are the very Antaci of our Periaci, participating thereby of whatever was opposite to you in either of the former Places, it is no wonder that you enjoy together neither Day nor Night, nor Season of the Year, nor any thing else of this Nature.

OPERATION VII.

To find where 'tis Day, and where 'tis Night, all the World over.

Compose your Globe, and all People that live in the illumina-ted Hemisphere, enjoy DAY at that Moment; and all that live in the Obscure One, NIGHT.

OPERATION VIII.

To know where at that Moment of time the Inhabitants enjoy nothing but DAY, and where nothing but NIGHT; as also when the DAY and NIGHT will be thus perpetual in any place subject to this Alteration.

Escribe with your Eye an Imaginary Circle about the where they Illuminated Pole, its Radius being the Distance from the have no said Pole to the nearest part of the Shade of Extuberancy, and Night, and all places within that Circle will have then no Night, and all where no places within the dark Circle of the like Radius, round the ob-Scur'd or obumbrated Pole will have then no Day: Now if you when 'tmill desire to know, when 'twill be in this manner perpetual Day or be perpetual Night, at any Place between the Poles and the Polar Circles, as any Place. (for

(for you know 'tis never perpetual Day and Night any where else) you have nothing to do but to measure with your String, or Compasses the Distance between the Place requir'd and the next Pole, which now for Examples fake, we will suppose the Northern Pole; I fay you have nothing to do, but to meafure this Distance; for placing one end of your String, or one Foot of your Compasses on the Intersection of the Meridian and the Equator, if you observe what Northern Parallel the other end of your String, or Foot of the Compasses (extended at the aforefaid Distance) touches, 'twill shew you by touching (v.g.) the Parallel mark't with the 10th. of April, and 12th.of July, that it begins to be on the faid 10th. of April, perpetual Day there; and so continues until the 12th. of July. Now if you measure from the before mentioned Intersection towards the Southern Pole, and find the End of your String, or Foot of the Compasses to touch the 13th. of October, and 9th. of 7anuary, 'tis certain that from the faid Day in October to that of fanuary 'twill be perpetual Night there, and consequently from the 12 of July to the 13th. of October, the Days and Nights fucceed each other after the ordinary manner.

OPERATION IX.

To find where the Sun is Rising, and where He is Setting, all the World over.

Ompose your Globe, and having consider'd the Confines or Extremity of the PRECEEDING and FOLLOWING Shades of Extuberancy, you may conclude that to all the Inhabitants under the first, the Sun is Rising, and to them under the Second, that He is then Setting.

OPERATION X.

To find where the Sun is Vertical at any time, i.e. what People have him just over their Heads.

THE Sun is always Vertical to those that lye in the middle of the Illuminated part of the Globe, i.e. to those that dwell under his then present Place in his Parallel; therefore (as I show'd you in the *first Section) if you Compose your Globe and * Op. 6. pag. hold up your String against the Sun from the Pole, till its II. Shade passes thro' the other, or from the Zenith, till it passes thro' the Nadir, 'twill cut the Parallel of the Day at the Suns true Place, and consequently show you who they are, that have him then just over their Heads; which happens (for Examples sake, on the 10th, of April, about our 6 in the Morning) to them that dwell about the middle of the Coast of Malabar.

OPERATION XI.

To know where they are Rising, where they are at Dinner, where at Supper, and where going to Bed all over the World.

His Operation depends on this Maxim, That it is the same I Hour with all People that have the same Longitude, that is to say, that live under the same Sami-hour Circle, or Semi-Meridian, therefore as the drawing of your String from the Where 'tis Pole, over half the illuminated part of the Globe, i.e. over the Dinner-time Sun's present Place, shows you that 'tis Noon or Dinner-time all the world with all that inhabit under the said String, so the drawing it over. over any Place distant 6 hours Westmand (i.e. over so many where 'tis the hours towards the less hand from the Vertical point) shows time of Rising where 'tis then all the World over sincthe Monning; or Time all the World to Rise; whereas had you drawn it six hours Eastmand (i.e. to Where 'tis wards your Right-hand,) it would have shown you where 'twas Supper time six in the Evening or Supper-time, and sour hours surther (i.e. all the World F 2

Where 'tis Bed-time all the World over

two hours short of Midnight, or the point opposite to Noon) where 'tis 10 of Clock, or Bed-time.

OPERATION XII.

How much any People (if it be Day with them) are past Morning, or want of Evening; and (if it be Night with them) how much they are past Evening or want of Morning.

over it, then see what Point of the said Parallel that runs over it, then see what Point of the said Parallel the Preceding shade of Extuberancy cuts, and if you count the Hour Circles or distance in time between the said Point and the proposed Place, 'twill give you (if it be there Night) how much it lack's of Morning; and the distance in time between the said Place and the Point made by the Following shade of Extuberancy gives you how much it is since Evening. On the other side, if it be Day there, the distance between the said Place, and Poynt made by the Preceding shade tells you how long 'tis since Morning, and the Following shade how long 'tis since Evening. Now if there be no Parallel that run's over or neer your said proposed Place, mount your Bead to it, and moving your said Bead on the Noose from the Pole it will describe a Parallel, and then you may operate as before.

The Reason or Demonstration of the Operation.
* Operato Sec. 1. pag. 14.

The Reason of the Operation is this; The shade of Extuber rancy getting every hour in the Aquator (as you saw * before) fisteen degrees, swill proceed in the same proportion on all Parallels over which it passes, therefore, if the Distance between any Point in the Aquator and the Following shade be the distance in time of the said Point from Evening or Sun-set, and if the distance there between any Point and the Preceasing shade be the distance of the said Point from Morning or Sun-rising, it follows that the distance between any Point in an Aquinostical Parallel and these two shades of Extuberancy that cut it, must be also it's true measure or distance in time both from Morning and Evening.

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OPERATION XIII.

To find the Sun's height in any Place, where the Globe shews 'iis Day, or his Depression where it show's 'tis Night; as also what People throughout the World see the Sun, at the same Height.

CUppose on the 10 of April (Having compos'd your Globe, and To find the I found it about 6 in the morning with you) you should de-Sun's height fire to know how high the Sun is at Rome, as also all the Peo- in any place. ple that then see him at that, or any other determin'd height, Measure by your String or Compasses, the nearest Distance between Rome and the shade of Extuberancy, and 'twill give your in any great Circle about 22 Degrees for his Height there at that moment. And the reason of it is, because when the Sun The Reason of (i.e. the Place where he is Vertical) is diftant 90 Degrees from the Operation Rome, then Rome fees him in his Horizon, and as soon as he gets above the Horizon (v.g.) 22 Degrees, his Rayes will illuminate beyond Rome 22 Degrees; for else there would not be always 90 Degrees from the Place where the Sun is Verticale to the Confines of the shade and Light, or utmost Extent of his Rayes; but the distance from Rome to the nearest part of the shade of Extuberancy, is the distance of his Illumination beyond Rome ergo 'tis his true Height.

In like manner if it be Night at any Place on your Globe, To find the and you defire to know how much the Sun is there depress'd or Sun's Depresunder the Horizon: take the Distance (as before) between the fion. faid place, and the nearest Term of the shade of Extuberancy, and that (for the former reason) will be the required Depres-

fron.

As for the finding out of all Places, that have the Sun (fup- To find all the pose 22 Degrees above their Horizon, you are only to lay the Places, that Plummet end of your String or Foot of your Compasses on the bave the Sun middle of the Coast of Malabar (where we now suppose the beight. Sun to be Vertical) and making your Bead or the other Foot of your said Compasses to lye on Rome, describe an imaginary Circle; and then all People under the faid Circle will have

the Sun 22 Degrees high, fince they are all distant from him like Rome; and thus you must operate in all other Cases.

OPERATION XIV.

To know what a Clock 'tis with you, the Italian, Babilonish, and Fudaic way.

How Aftronomers begin tation of Time

I OU are first to know that as England, France, Spain, Denmark, Sweden, most part of Germany, and many otheir Compu- ther Places follow the Astronomical account in their Diurnal Computation of time, with this only difference that the Aftrenomers begin at Noon, and fo go on from 1 to 24; whereas the aforesaid Nations begin at Mid-night, dividing the whole Natural Day into twice twelve hours; I say, as these Nations begin their Account at Mia-Night, so the Italians do theirs at Sun-set, continuing to 24 without interruption, after the Athenian manner of old, which is also now usually observed in Bohemia, Austria, Silesia, crc. On the contrary some Places in Germany,

How the Ita-

lians.

and particularly Novemberg, still follows the antient Babilonian or Caldean Way, as commencing their 24 hours from Sun-rifing: therefore the difficulty and feeming Confusion of coun-

How the Bubilonians.

ting by either of these 2 last wayes proceeds from the Sun's inconstancy in its Rifing and Setting; for when he is in the Aquinoctial our Globe show's us the hour, as soon after their manner as our own: As for example, if you would then know what

To find the Babiloniff and Italian bour when the fun u in the Aquator.

hour 'tis with you, the Babilonian way, Hold up your String against the Sun, and moove it on it's Noofe from the Pole, till the shade fall on the contrary Pole, (i.e. look what a clock 'tis the * fecond Way, and where the shade of the String cuts the

Equator, the Roman Figures there will give you the true Babilonish Hour. Or (which is all one) see what a clock 'tis by the

* Op. 10. sec. Shade of Extuberancy, or * 3d way, and finding the said shade to 1. pag. 14. tall, surpose, on the 9 a clock hour-circle in the Equator as the then true hour after our English Fashion; do but cast your Eye

To find the I- on the Polar Circles, and the faid 9 a clock hour-circle, will cut telian Hour when the Sun there at the Roman Figure 3. so that you may conclude it then is in the A- 3 a clock the Babilonian way. Nor does the Italian manner quator. m1materially differ from this; for 'tis but adding 12 hours to the 3 found as before, and then 15 will be the true hour after that

Now if you would know the hour when the Sun is out of the To find the Aguator (as for example, on the 1 oth. of April) consider the hour both the Parallel of the Day, which giving you at first fight about one said ways at bour for the Ascensional Difference, (as I show'd you in the for- any time. mer * Section) do but add this hour to the three found, as we now show'd you, and 'twill give you four for the true Babilonian hour; whereas if you fubstract it from 3 (i. e. from the aforefaid 15.) you have the true Italian hour; and thus you are to proceed in all other cases; Only remember that when the Sun is in his Southern Declenfion the Substraction of his Ascentional Difference gives the Babilonian, and the Addition of it the Italian hour.

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But if you would have yet an easier way of performing this, ing at any consult the 12th. Operation, and the distance in time there from time the Ba-Day gives you the Babilonian, and the distance from Night bilonian and the Italian hour.

As for the fews, they devided the day always into 12. equal parts, which they called hours, as appears by our Saviours de- of the Judaic mand: Are there not 12 hours in the Day? therefore when way of Computhe Sun is in the Equator (as it happened about the time of ting time. the Passion) this and the Babilonish way are the same, for then the 3d. hour is 9. a Clock with us; and our 3 in the afternoon is their 9th hour; so that at 6 our way, or at 12 theirs, the Sun Sets, and the Night begins, which they also devided into 12 equal parts; I say, this is the same as the Babilonish way, when the Sun is at or about the Aquator, and consequently easy; but afterwards, by reason of the strange inequallity of both Day and Night, the Computation must be troublesom, especially if we use Reduction (the common prescribed way on the Globe) for the Summer days with us contain above 16 of our hours, and the Winter ones not half so many, and yet both kind of Days are to be devided into 12 equal parts or hours; Nor were the fews: the only people that reckon'd thus, for the manner was in use among the Romans, ias we fee by Perfius his Drunkards, who. lay a Bed to digest their Wine - Quinta dum linea tangitur Umbra. Naythe Greeks followed it also, and had Machines or Clocks (as Achilles Tatins tells us) which could (notwith-

A most ready way of find. Italian Hour all the world

standing the forementioned strange inequality of Dayes) meafure their Time.

A most ready may to find the Judaic Hour.

But this seemingly odd and exotic account, may very exactly and expeditely be perform'd by our Globe; for, if the Globe maker devides each diurnal Parallel by distinct specks or pricks into twenty four parts, that is to fay; if he devides that part of each Parallel above the Horizon into 12 equal ones, and that below it into the like number, you have nothing to do but to hold up your String against the Sun, and if you move it from the Pole on its Noose, 'till its shade passes over the contrary Pole, then upon what prick soever the shade falls, that will be the requir'd hour; and in like manner if you know the Sun's Depression, draw but your String over his then Place, and it will cut the Parallel at the true Judaical time of the Night.

Why the days of the Week being called by the Names follow not each other af-* h Saturn. 4 Jupiter. of Mars. ⊙ Sol, 9 Ve-

These Unequal Hours were also called Planetary by the Anof the Planets cients, who allowed to each a Planet to govern it; so that the first hour (suppose) on Saturday, belonging to Saturn, if you ter the order go on still in the usual Coelestial Order, as 'tis exprest * in the of the Planets Margent, and consequently assign Jupiter to the second hour, Mars to the third, &c. the 25th (i.e. the first hour of Sunday) will happen to the Sun's Lot, and the first of Munday to the Moon's, and so forward: and thus you may fee how it came to nus, & Mer- pass that the dayes of the week succeeded in the present order, cury, D Luna. and not according to that of the Planets in the Heavens, that is to fay, why Dies Luna (or Munday) and not Dies Veneris (or Fryday) immediately follows Sunday.

The Advanlian way.

I shall now end this Discourse, after I have told you, that if tage in reck- we English-men think these Computations strange, they that use oning the Ita- them, wonder as much at ours; nay, each man pretends some particular Convenience and Advantage by his Method; For first, an Italian says, that without breaking ones Brains no body can tell our way when the Day ends, so that idle men, who usually hate computing do often couzen themselves, and take false measures in their Affairs, for (continues he) if they chance to get up at 8 of the Clock in Winter, they fancy a whole day (even St. Barnabas's) before them, when as this Hour or early rifing to Him, is 16 of the Clock, which informs him at the very instant, there are but 8 hours to Night.

The Advin. tage in reckouing the Babylonian way.

The Caldean on the other side urges that Morning, being the most precious part of the Day, is fittest to be nicely known, and

and tho' his Hour gives him not presently the Distance to the Evening, yet it so alarms him, as to what relates to the Morning, that he cannot make the least slip therein, without being at the same moment conscious of his failure.

Lastly, the few approving both Reasons highly, triumphs in his way; for he no sooner looks (he says) upon his Dial, but sees there not only what hours are past, but also what remain,

and are yet behind

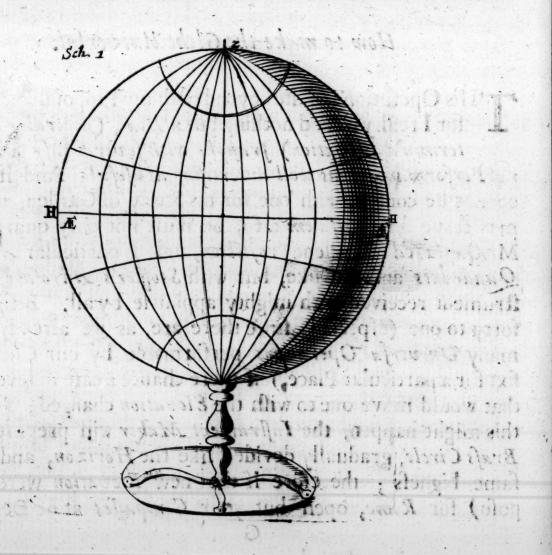
But notwithstanding all these shews and pretences of Reasons our Account is so far from coming short of any, that in reality it surpasses all; for we not only know exactly what we want every moment of Noon (a thing of mighty Concern) but can appoint positive hours all the Year long, for any Employment whether private of publick, whilst these other ways (by reason of the Suns inconstancy in Rising and Setting) have all orderly and set times (as when to Dine, when to Sup, when to Rise, when to go to Bed, &c.) still mutable and sleeting.

OPERATION XV.

How to make the Globe Universal.

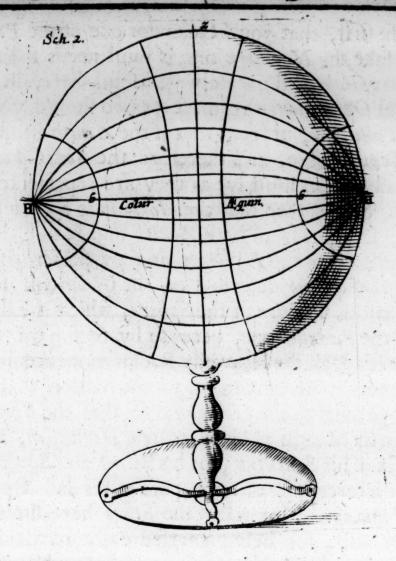
This Operation is quite beyond both my Proposal and Design; for I really intend nothing but a Dial, (according to a Determin'd Elevation) fraught with several easy and natural Performances; as well divertising as useful; And if a man connot be content with one for his Study or Garden, unless it may ferve for ferufalem also, he must not only quarrel with Mr. Oughtved's excellent Projection, and all particular Analems, Quadrants and the like, but with Stoffler's Astrolabe, an Instrument received with mighty applause by all. Besides, 'tis forty to one (especially since there are, as we already see, so many Universal Operations performable by our Globe, tho fixt for a particular Place,) if there chance a case in seven years that would move one to wish the Elevation changed; Yet least this might happen, the Instrument Maker will prepare a thin Brass Circle, gradually devided like the Horizon, and of the fame bigness; therefore if the new Elevation were (suppose) for Rome, open but your Compasses at 90 Degrees in any any of the great Circles; or, take the same distance with your String and Bead, and having designed by your said Compasses or String any two Points thus distant from Rome, clap over your new Horizon so, that its devided edge rests on the said two Points; or in short, let Rome be the Pole of the Brass Circle, and twill cut all the Equinostial Parallels, as if the Globe had been made for that City, and consequently you will soon have there, the Suns Rising, Setting, Ambitude, Ascensional Difference, &c. Moreover the Circle being exactly made, will stick of it self, or, at least by the help of any scrap of Paper between, so that if at any time you set but the Plumet-end of your String on Rome, you may then hold it down with one Finger, and operate as you would do from your own Zenith.

But fince I am fallen upon this needless affair, and since the Operation is in effect the changing of the fixt and standing Site of our Globe, 'twill be perchance not amiss to inform you (if you are not already well verst in the Sphere) that there are three different and distinct Positions of it, which you will better comprehend, if you consider your self in these three Places.



Suppose first, that you were under one of the Poles, and for Of the Paral Example sake, the Northern one, it must needs follow that that let Sphere. Pin on your Globe will not only be useful there, in relation to the feveral Operations that must (as we show'd you) be done from the Polar Pin, but from that of the Zenith also; because now 'tis the Zenith there, and therefore the South-Pole being the Nadir, all Circles must lye as they are represented in Scheme the first. Seeing then that the Horizon is a great Circle, and always 90 Degrees from both Zenith and Nadir, it will necesfarily happen that the Horizon and Aquator must concur. fo that the Equator describ'd on the Globe will serve for an Horizon in this Position of the Sphere, which is called by Geographers the Parallel one, because by reason of the concurrence aforesaid, all the Heavenly Bodies move according to their Diurnal motion i.e. according to the motion of the Primum Mobile) parallel to the Horizon; so that the Sun cannot Set during the fix Months of his Northern Declenfion, nor rife during the fix of his Southern; for his Rifing and Setting imply the cutting or intercepting of some part of his daily Road or Track by the Horizon. Nor want the Stars here their particular Properties also; for being carried daily on the Poles of the World, and consequently moving parallel to the Aquator, all that are above the Horizon cannot go under it, nor the others emerge, unless some, by their proper motion after a long series of time, change that Order. Having then in this Sphere the Zenith and Horizon, whatfoever is performable by your own Zenith and Horizon, may be here (mutatis mutandis) perform'd after the same manner.

Leave then but this Pole, and every step of it under any Of the Right Meridian (as suppose the Solstitial Colure, or 12 a Clock Sphere. Hour (ircle) makes it no longer your Zenith, but to decline more and more towards your Horizon; so that by that time you get to the Equator, both it and the opposite Pole will be 90 Degrees from your Zenith, and lie consequently just in the Horizon, as appears by the Second Scheme, which is called the Right Sphere, because the Horizon (which is here represented by the Aguinoctial Colure or 6 a Clock Circle) cuts the **Æqua**

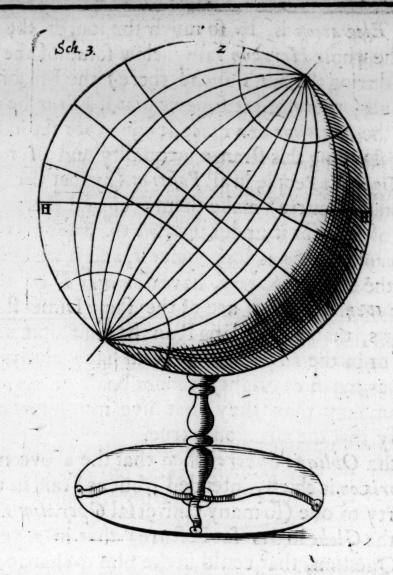


Proprieties
belonging to
the Right
Sphere.

Aquator and all Parallels to it at Right Angles, and in half; therefore it appears plainly now, that both the Sun, Stars, &c. are here to be just 12 hours above, & 12 below the Horizon, Besides as in a Barrel every Concentric Hoop or Circle whether small or great, turns just about as the Barrel does, having all correspondent Points up and down at the same Instant; I say, as it happens thus in an ordinary Barrel so it must also happen here; for the Equator and its Parallels do not a little represent such a Figure, and therefore the Sun must be as many Hours in his Tourney round the Tropics as the Equator it felf; Nay, any Star rising with a Degree of the Equator which is its Right Ascension, as we hinted in the last * Section) must still accompany each other, and having past under every hour Circle together) set at last in the same Order. To conclude, your String from the Zenith will be as useful as formerly; for your Bead will as well shew you what you here desire, as at your own Dwelling.

Op.17. p.47.

greater



As for the oblique Sphere which is the third and last Position, and here express'd by the third Scheme, we are in it (you must Sphere. World that are in neither of the two former ones; for take any point not under the Poles or the Equator for your Zenith, and twill be impossible to describe an Horizon or Circle 90 Degrees fromit, which cuts not the Aquator and all its Parallels ob-'Tis this Obliquity then that gives name to the Position, and 'tis this that makes the great inequalities in days and nights; for if the Horizon has a greater portion of one Diurnal Parallel above it, than of another (as it must needs have by its flanting) 'twill follow, when the Sun is in fuch a Parallel, that the Day will be longer than when the portion was less, and confequently fince more of one Parallel is under the Horizon than of another) that one Night is shorter than another; and seeing the nearer the Pole is to the Horizon, the more equally it cuts the said Parallels, and the further it is from it, the greater the inequality happens to be, 'tis no wonder that by how much the

All Positions (taking the year round) enjoy an equal (bare of jenc:.

greater the Elevation is, by so much the longer the Days are: and when the whole Horizon falls below some of the Parallels, that then (during the Sun's aboad there) the Inhabitants have no night at all; therefore it follows that if a Star be neerer the Pole than is the Latitude of a Place, it can never set in that Place. Yet notwithstanding this strange inequality and disproportion of Day and Night, all People in all Positions (by that time the Sun finishes his annual Course) make them even, and thereby enjoy an the Sun's pre- equal share of both, for if under the Pole the Sun be six months a. bove the Horizon, he is as long under it, and if we and the Rest, that live in the Obtique Sphere, have Summer Days of a mighty length, our Winter Nights are of the same Dimersion; therefore it follows, that at the long Run the Inhabitants under the Equator, or in the Right Sphere (who have always 12 hours of Day and as much of Night) cannot boast of having more of the Suns Company than they that live in the two other, and consequently that the assertion is true.

'Tis in the Oblique Sphere then that the above-mentioned Brazen Horizon is chiefly intended; but as I said in the beginning, 'tis forty to one (so many Universal Operations being perform'd by the Globe in its fet Posture) that in 7 years a man lights on a Quettion, that could invite him to change it, were it moveable as other Globes are; so that having show'd you that (in case of Necessity) it may be in essect altered even without

stirring it from its Pedestal. I shall proceed.

OPERATION. XVI.

How to take the Elevation of the Pole in any place erson at the ness neut of the Peffich. at inequalities in days and

CUppose you were in a strange Place, and that your Globe being one, that had bin fitted for London, you defire to know the present Elevation. Expose your Globe to the Sun on a Meridian Line with the Pin or Needle in the * Hole on the Parallel of the 10 of April, or true day of the Moneth, and observing at 12 a clock (when the Sun comes into the Plain of the Globes Meridian) that the shade of the said Needle or Pin loses not it self as it would do were the Sun directly opposite to it, for so it had happi'd at

Vid.Op. 3. sec. 1.pag. 8.

London, or in any place in the Latitude of 51g 30. I say, having thus expos'd your Globe, and observing this, move your Pin or Needle from Hole to Hole, or from one Degree of the Meridian to the other, 'till it's shade be wholly lost, and finding the said Needle or Pin on the Parallel (suppose) of June 11th. which is about 11. 30 higher then it's proper place (to wit the Parallel of the 10th of April) you may conclude that your present Elevation is 63 degrees, i.e. 11. 30 higher than the Globe's; whereas had you bin oblig'd to move your Needle or Pin so many Degrees lower than the 10th of April, your Elevation had bin but 40.

The Demonstration is obvious, for since the Earth is round; The Demonsor as nothing perchance proves it better, than the Experience we stration. have, that as so many miles (suppose 60) elevates or depress the Pole one Degree, so just 60 Miles more elevates or depresses it another: I say, since the World is round, and that the De-How the grees of the Globe answer to its Degrees, it must follow that the Earth is prodifference between the Pins situation now on the Globe and v'd Round. where it would have stood on it at London is the true difference

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OPERATION XVII.

How to know in what Elevation the Sun Rises or Sets, an hour, or any other space of time, earlier or later than he do's in the Globes Elevation.

If the Sun rising at London on the 10th. of April about 5, and setting about 7, you would know in what Elevation or Latitude he then rises, (for examples sake) at 4 and sets at 8, take the distance of 90 Degrees with your String or Campasses in any great Circle, and placing one end of your String or one foot of your Compasses, where the Parallel of the day intersects with the Hour-Circle of either 4 in the morning, or 8 at night, observe where, or at what point the other end of your said String or other foot of your said Compasses touches in the Meridian, or 12 a Clock Circle of the Globe, and you will find it to be at, or about 8 Degrees and 30 Minutes, beyond the Zenith towards the North Pole, so that the Elevation required is greater than your

your own by those 8 Degrees and 30 minutes, that is to say the Elevation is that of 60 or thereabout; whereas had your String or Compasses touch't 8. 2 30'. on the other side of your Zenith, the required Elevation would have been less than your own so many Degrees, i.e. it would have been that of 43 Degrees or thereabout.

The Demon-Stration. This appears true by placing your Brazen Horizon, or by describing an imaginary one over the two points made by the Intersection of the Parallel of the Day, and Hour-Circles of 4 in the morning and 8 in the evening; for in the Elevation belonging to such an Horizon, 'tis evident that the Sun rises at 4 and sets at 8. Now the Pole of every Circle being 90 Degrees from it, and the Point in the Meridian being 90 Degrees from the aforementioned Intersection, it follows that the said Point in the Meridian is the Zenith or Pole of this new Horizon, and consequently by being distant from the Aquator 60. Degrees, that so many Degrees is the Latitude or Elevation required.

The END of the second Section.

SECTION IN A CONTRACT OF THE CONTRACT CONTRACT CONTRACT OF THE CONTRACT OF THE

Of the Moon.

Having now finish'd with the Sun, wee'l make a step, if you please, to the Moon, and show you how to resolve all the useful ordinary Questions concerning her, whether we see her by Night or by Day; for tis equal to us whether she shines out right, and consequently casts a shade, or appears only faint and wan, by reason of thin Clouds, or by the excess of Light during the Sun's aboad above the Horizon. Let us then begin with her Almucantar and Azimuth, as being the Basis and Foundation of all Operations here relating to her; nor can there be the least difficulty in any of them, unless perchance in the 7th.

fince they have so great a Correspondence and affinity with those already handled in the former Sections.

OPERATION I.

To find the Moon's Almucantar or Height.

THIS is to be perform'd as well when she cast's a shade, as when she cast's none, by the two first ways of finding the Suns Almucantar, and therefore consult the * second Operation * pag. 5. in the first Section.

To know the atooms Dictention from the

OPERATION II. of ent of Algin

faccording to the firegoing Example) the being Degrace

To find the Moon's Azimuth.

THIS is also to be found by the two first ways of finding the Sun's Azimuth, treated of in the *5th. Operation * pag: 16. of the first. Section.

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To find her true place on the Globe.

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If the casts no shade, her place is to be found by her Almucantar and Azimuth, as we hinted in the 6th. Ope pag. II: ration of the first Section, since she must ever be where these two Circles intersect; But if she shines out cleer, you have nothing to do (having plac't your Globe on a Meridian Line) but to see what hour the shade of the enlightned Pole, or that of your String (passing over both Poles) mark's; for this giving you her hour Circle (which we'l call the Lunar hour hereaster) her height or Almucantar must needs tell you in what part of the said Circle she resides. This Operation is to be well understood and readily perform'd, seeing

most that follow are as it were Corollaries from it; and for the better illustrating and explaining them, we will imagine the Moon's Place to be in the hour Circle of 2 in the Afternoon, about 43 Degrees above the Horizon,

MODERATION IV.

To know the Moon's Declension from the Aquator.

HIS is only the nearest distance of her true Place from the Equator, which your Bead or Compasses will show you to be about 12 Degrees Northward, if (according to the foregoing Example) she be 43 Degrees high, in the hour Circle of 2 in the afternoon.

OPERATION V.

To find the Moon's Diurnal Parallel, and consequently how to Compose the Globe by the Moon.

BY the Moons Diurnal Parrallel I mean a real or imable to her present Declenson, which by the Cormer Operation we suppose to be about 12 Degrees; Having therefore this Parallel you may compose the Globe by the Moon, as you

* vid. pag.8. do by the * Sun. O 15:

done

A Memoran.

And here you must remember, that the finding of the Parallel implies at first a Meridian Line, yet the knowing how to compose thus your Globe will not be useles; for now you are no longer confin'd to one Place or Line, but may compose it where you please by the help of the said Parallel. and the hand hard gother to our Globe of a Meridian Line)

to first wine in a tice that earlie of the sal planed Pale, or

Att. Jours (care to de tode to de l'ester) mariès: l'ar is giving from home Circle (which we'l call the Loner near hereafter seight er estarreautur must needs tell

A 9.0 of the fact of chale the relides! This Ore a bow all dedictions and readily performing forms

OPERATION. VI.

To find the Moon's Bearing according to the Points of the Compasse.

THIS is to be perform'd after the way of finding the Sun's Bearing, in the * 7th. Operation of the first Section; * p. 12. for if you draw your String from the Zenith over the Moons present Place, the said String cuts (by our Example) the Horizon at S. W. and some few Degrees towards the South for her then Bearing.

OPERATION VII.

To know what a clock it is by the Moon.

Here is no Operation treated of so intricate as this, and therefore if the Reader (who would have his Curiofity fatisfy'd) has not Patience enough to descend to a little niceness, he had better fall upon another Subject; but tho' we may be formewhat long at first, in laying down and explicating all Particulars, yet at the end we will contract the whole into half a dozen Lines, and thereby make the Operation very expedit, and eafy; I fay, there is no Operation fo intricate as this; for, the Moon by reason of her different Place in her Epicicle, is so inconstant in her dayly Elongation from the Sun, that formetimes the spends from (v.g.) her Conjunction to her first Quarter above 8 days, the at another time a great deal less than ? will forve the turn; and to this variety and skittishness is the fpace also between any of her other changes liable. If then her distance from the Sun be so uncertain, and yet is the thing that must be known before her Place, or shade on the Globe can give us the bour we feek, how strangely fallible is the usual way (as welbin fome Authors of Note, as in ordinary Almanacks) of finding it, to wie, the adding of as many 48 minutes to the hour the thows on a Dial, as the is days old; for the Tables, made in pursuance of this Rule, suppose her always on the 1 yth of her Age Age to be at Full, which may happen (as I now mention'd) not only much sooner, but also much later, so that most commonly her true Age and the faid Tables are at variance; nay, when they agree, there can be no Reliance on them, feeing that if (v.g.) at 6 they show tolerably what a clock it is, yet by 12 there may happen an Error of near a Quarter, by reason that she is every moment at a new distance from the Sun, and at one also which prefently becomes very sensible. Thus therefore we fee that there must be Exceptions and Restrictions in any one Rule that appertains to this business; nor isit to be perform'd by an Instrument in a trice, as the Operations commonly are belonging to the Stars, that have a Regular motion, or to the Sun, whose Extravagance is not soon perceptible; I say, thus we see that there must be here Exceptions and Restrictions, and in truth nothing but a down right Astronomical Calculation can really perform it; yet since such a critical Exactness in the hour is never necessary in our ordinary affairs, I shall propose this method, which will at least come always very near the Mark.

Flow you are to operate:

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When you desire to know what a clock it is by the Moon, take an Almanac (for if you would only have her true Age, you must recur to one, or to something analogical) and reckon therein how many dayes there are in the present Quarter from one Change to the other, i.e. from New Moon to her First Quarter, or from her first Quarter to her Full, and so on; for I call any of these four Aspects a Cardinal Point, or Change, and the whole time between one Change and the other a Quarter; I fay, Reckon how many Days there are, in the then Quarter, and you will find either 61, or 7, or 8, fo that if the number be 61, her Elongation from the Sun is 5 Minutes and per Diem, if 2 Days 512, if 7 days and half, 48; and lattly if 8 Dayes, 48. I mean not nevertheless that from Change to Change there may not sometimes happen 6 days and 16 hours or 6 Days and 20 hours, and several fuch Fractions and Deviations from the Positive Terms prefixt by me: but fince the forementioned whole and half dayes will bring us to a knowledge exact enough of the hour fought for, we call 6 days and 6 hours 6 dayes and a only, as coming neeres to it than 7 whole ones ; In like manner, we call 6, and 20 hours 7 days, and deal in this Proportion with all other number of days

and

and hours which the Ephemerides or Almanack give us concer-

ning the length of the requir'd Quarter.

And here you may be pleas'd to remember also, that it A Memoran-would not be amiss, in case you exceed much any of the fore-said terms, to add or cast away sometimes a minute or a little more, as you shall see Cause; For if (v.g.) you find the Moon to be six days and 17 hours in her journey (which according to our former Directions is to be reputed only six days and \frac{1}{2}; and consequently the Elongation 55' \frac{1}{2}, you may then cast away 1'\frac{1}{2}, because of this great excess above the half day; and if you should find her at another time to be 7 days and twenty hours, i.e. eight days, you may add for the want of the four hours a minute, and make her dayly Elongation, 46 instead of the forementioned 45; but here you may do as you you please, for the error will not be considerable.

These Particulars being premis'd, let us come to an Exam-An Example...
ple; and Suppose then that on the fifth of January, finding the
Moons shadow to marke two in the asternoon on your
Globe for the Lunar hour, you should desire to know the

true, or Solar hour.

First your Almanac can tell you not only that the Moons last Cardinal Point, was (v.g.) her Conjunction, but how many Days and Hours she spends in going from it to the next Cardinal Point; for finding there her faid Conjunction to be on the first day (suppose) at seven at night, and that she comes to her first Quarter on the ninth day, near the same hour, you may prefertly conclude she is 8 whole Days in this. Voyage, and consequently that her Diurnal Elongation from the Sun will be 45 minutes. Now because the said fifth day is the 4th of her Journey, if you multiply 45 by 4, or lookin the Tables (which we shall presently show you) belonging to her 8 Days Journey, you'l have three hours for the time that she is behind the Sun, fo that the Solar or true hour must be five at night, wanting four minutes; for you are always carefully to substract two minutes for every hour the Moon wants of compleating her whole Days march, which in the present case happens, not before seven at tright; whereas you must have added them, had the Solar hour hin nine at right, because then her Elongation from the Sun would have Been 4 minutes more than the aforesaid three hours.

Tis:

Two Memo-

Tis in this manner you are to opperate in all cases; but before we proceed, take these two Memorandums with you. First, That by the Moon's compleating a day's journey, I mean 24 hours after the time (let it happen by night or by day) of her entring into her last Cardinal Point; as for Example, If the comes to her Conjunction, or any other Cardinal Point, at 7 in the Evening on (v. g) Munday, then at 7 in the Evening on Tuesday, the has compleated one day's journey, and at the same hour on Wednesday two Dayes, and so on till she comes to her next Cardinal Point. The second Memorandum is, That whereas (in the late Example) her Elongation from the Sun was three hours (because you sought what a Clock it was on her sourth days journey from her Conjunction to her First Quarter, at the Elongation of 45 minutes per diem.) Now had the been thus advanced in her Course from her First Quarter to her Full, or from her last Quarter to her Conjunction, you must have added 6 hours to the faid 3 hours, so that then the true hour would (instead of cat night have been 11; and this is to be a general Rule.

The reason or Thu demonstrati- any time on of the O-said. peration. know the contraction of the contraction

Thus much then for the way of finding what a Clock it is at any time by the Moon, and now let us make good what we have First we see, that to know the Hour by the Moon, is to know the difference between the Lunar and Solar hour, i. e. between the hour Circle she is in, and that in which the Sun happens (at the same time) to be; or, in other Terms between the hour she marks on the Globe by her shade, and that which the Sun would mark did he then appear; Now seeing that in her Course from one Cardinal Point to the other, she feldom spends the same number of days and half days, it sollows (as we hinted in the begining) that no certain number of minutes, can be allowed for her daily Elongation; But if we divide 6 hours, or 360 minutes (i. e. her total Elongation from one Cardinal Point to another) by the Days and half days the spends in the journey, the Quotient must be her Diurnal Elongation (at least to sence) during that Quarter. Now since the Diurnal Elongation is, as you fee most commonly above three quarters, and somtimes almost an hour, the Horary one must be (as I said) confiderable, seeing in the space of every 7 hours it may amount to above a quarter more; therefore this inconvenience we obviate by allowing two minutes for each hour after her compleat days journey; and fubstracting them from what she wants of it.

Here I confess there may be an Error, but it is hardly worth a memoranthe mentioning; for when she is either 8 days, or 7, in her
journey from one Cardinal Point to another; i.e. when her
Diurnal Elongation is either 45', or 51' and \(\frac{1}{2}\), the difference
from 48 minutes a day (or 2 minutes an hour) cannot be but
3' and \(\frac{1}{2}\) in a whole day: nay, when her Elongation is 55' and \(\frac{1}{2}\)
i.e. when she spends 6 days and \(\frac{1}{2}\) in her voyage, the difference is but 7' and \(\frac{1}{2}\) from the aforesaid 48 minutes; nor can
this happen till the end of every compleat days journey, and
consequently is not perceivable for the greatest part of it. But
since we here see where and how any error may arise, it is easily
remedied by an Allowance, if any man thinks it worth the
while to be so exact.

As for the Reason why, if she be in her Course from her Why 6 hours first Quarter to her Full, or from her last Quarter to her Con-must be added junction, we must add always six hours to the Elongation, which sometime to our Calculation or the Tables give, it is, because the said Elon-the Tables.

our Calculation or the Tables give, it is, because the said Elongation is only the precise time of her Departure from her last Cardinal Point, whereas if she be past her first quarter in her fourney towards her Full, the is fo much and fix hours more, i. e. fo much and the fix hours, which happen from her Conjunthion to her first Quarter. Now in rigor we should add twelve hours to the Elongarion we find, when the is gone from her Full, towards her last Quarter, but seeing she is in the Plane of the same Hour-Circle or very near it, both at Full and in Conjunction, therefore the bare adding the faid simple Elongation will ferve as well in one case as in the other; for if, the Full Moon (at suppose 2 of the Clock at night) casts really her Shadow on the Hour-Circle of 2 in the Afternoon, yet there's no need of hints (the thing being fo plain) to prevent your mistaking Day for Night. The like also is to be said of the last Quarter, whose Elongation should be in truth eighteen hours, but the additional fix hours (as we allow her after her first Quarter) are sussicient, since no man can be so ignorant as to take the Morning for the Evening, notwithstanding the Luc nar bour should be upon a Morning Hour-Circle. To facilitate then this Operation (least what we have already said has proved tedious) we will conclude (as I promis'd) with a short Reca-

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pitulation or Abstract, as also with the Tables of her daily Elon. gation, let the time be what it will (as we faid) that the spends in her Journey from one Cardinal point to the other.

The Abstract of the Operation in finding the true Hour by the Moon according to the late Example.

S for the Almanac, there are three things (we fee) it informs us of, viz. 1. The Hour when the Moon came to her last Cardinal Point. 2. How many days she is going from the said Point to the next; and, 3. In which Days fourney she is at present. Knowing then, according to the late Example that the Moon will be eight days running throu' her Quarter, and that the is in the fourth Days Voyage; 'twill follow that the fourth day in the Table (whose title is eight dayes) will tell you that her present Elongation from the Sun is three hours; fo that the Lunar-hour being two in the afternoon, the true hour must be just five at night; only twice two Minutes are to be abated, because she lacks a hours from compleating her said fourth days voyage; for your Almanack (according to our supposition) informing you that it was seven at night when she set out from her last Cardinal Point, it must be still seven at night before she compleat's any whole day's Journey during that Quarter.

This then is the fumm of the whole Butiness, nor need you trouble your self with any other Reflexion unless it be to add fix hours (as I already faid) to the Elongation, in case she be going from her first Quarter to her Full, or from her Last to her Conjunction. And to conclude take notice, that the hour (if you see the Moon,) may be as well found by day as by night, for her Place on the Globe (which the third * Operation show's

the Mirane, is the internal of the Committee of the Commi

a west for how (a respect to the contract of

how to find) is always the true Lunar hour.

Tables of the Diurnal Elongation of the Moon from the Sun, whether she goes in 6; 7,7;, or 8 days, from one Cardinal Point to the other.

	Days	Days.	ĪI
Days from her Cardinal Point.	Card. Point. 0 0.0. 1 0.55. 1 2 1.51. 3 2.46. 2 4 3.42.	Card. Point. O 00. I 0.5 L. 2. 2 1.43. 3 2.34. 4 3.26.	Elongation.
27 50 50 50 50 50 50 50 50 50 50 50 50 50	54.37.5 6 5.33. 6 6. o. Hor.min.	5 4.17. 2 6 5.9. 7 6.0. Hor.min.	

nia to nia to	Days.	21 350 -61 151 5 22 150 150 150 150 1	Days.	1
	Card. Point.	can be as a para a construction of	Card. Point.	10
nt.	1 0.4	n. her	0 0.0.	
eys from ber rdinal Point.	21.3	ASTT B	11.00-0.45	
For	3 2.24	inga is	3 2.1 5.	Elongatio
Days	4 5500 - 3410	Elong.	142 -te 3.00	flon
80	6 4.4		3.45.	
of mo	7 5.30	i are informed	4:30.	
at mails	7 6,0.	CONTROL WALLE	8 6.0.	
. coin	Hor.m	rs, and fift-	Hor mi	9.

These Tables are to be onthe Globe in the most vacant and free parts of it.

OPERATION VIII.

To know how many hours the Moon has been up, and how many she lacks of her setting, as also how long she is to be that day above the Horizon.

His is done by numbring the Hours or Hour Circles between the Moons place in her Parallel on the Globe and the intersections of her said Parallel with the Horizon; for having found that her Parallel cuts the Horizon in the East at the five a clock hour circle, and in the West at that of seven. and feeing that her present Place is (v.g.) at that of two in the afternoon, you may conclude that the has bin up nine hours wanting eighteen minutes, that is, eight hours and forty two minutes; and will-fet within , hours wanting ten minutes, or four hours and fifty minutes; for the Moon goes from East to West (by the Motion of the Primum Mobile or Motum Raptus) two Minutes (as we suppose) every hour (take one time with the other) flower than the Sun; which happens by her being too quick for the Sun in her own Motion, that is to fay, in the Motion of the Center of her Epicicle, which carries her from West to East; therefore the Moon according to the present Example or Supposition will be above the Horizon fourteen Hours wanting twenty eight Minutes, a a about thirteen hours and a half.

OPERATION IX.

To find at what a clock the Moon rifes and fets.

By the last Operation you are inform of the hours from her present station to her Rising and Sering, which happing in the Example to be about eight hours and fourty two Minutes for the one, and four hours, and fifty minutes for the other, it must follow, (having found the true hour to be within four minutes in the Morning, and will set at hine and source fix minutes are Night.

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Shade, you have not only a view of what people feether in her rien condition, Kut ma M.O L.T.A.R.B.P.On) perceive by

To find how long the Moon Shines every night.

HAving found by the precedent Operation, that the Moon fets at 9 and 46 minutes at night, and that the Sun (by the 12th. of the first * Section) fets the same day, (suppose the 8th. * p. 16, of February) at 5 in the Evening, twill follow that she shines four hours and 46 minutes.

the shows you. IX di NO IT A REPORTS to the test of the short of the s

To find when the Moon comes to South, and consequently when tis high water at London Bridge.

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Having found by the * third Operation the Moons place to be in the 2 a Clock Circle, you thereby fee that she is pass the South 2 hours and 4, minutes; Now since it is always High-mater at the Bridge three hours after her coming to South, and since the Solar or true hour is (according to our Example) 5 at Night, it follows 'twas High-mater at 4 minutes before 6, and consequently twill be high water again at the same hour next morning, and 24 minutes; for from one Tide to the other there are always about 12 hours and 24 minutes.

OPERATION XII.

To know in any Eclips of the Moon, what Countries see et wholly, what in part, and what not at all.

PLACE your Globe on a Meridian Line, or otherwise Compose it, and when you percieve the Moon to begin to enter into the shade of the Earth, consider (as you do when you seek by the *Suns Rays where 'tis day and night) what part of the *Op.7.sec.2. Globe is illuminated, and what not; for, since she appears to all page 33. Countries that lie in the Light, and is hid from those in the Shade,

Shade, you have not only a view of what people fee her in her then condition, but may (till her total immersion) perceive by her illumination how the Countries, that lye in or near the Following shade of Extuberancy, loose every moment the fight of her, and consequently, who they are that took leave of her in the beginning of her Eclips, who when she came to half of it, and who when wholly obscur'd, with infinite more Reflections of this nature. On the other fide you may find, how some that lay in the preceding shade of Extuberancy saw nothing of her at first, but now begin to discover her in her Angony; and if you draw on the Globe a little Circle with Chalk or the like, in the Confines of the obscurity and light, just as she begins to be wholly in the shadow, you will discern (by the space between the said Chalk and the new shade of extuberancy at her Emersion) what people never fam her, the she were above their Horizon. Infinite are the Reflexions (as I said) of this nature, but these are fufficient to flow you how to make more your felf; so that now I will end after I have remembred you; that the Sun being by his Opposition in the same hour Circle with the Moon, especially in all Central Eclipses, nay he is so (as to sense) for some time both before and after fuch Eclipses; I say, the Sun being so, you may therefore not only (by the bare shade of the String, or that of the illuminated Pole) know what a Clock it is from time to time in the Polar Circles, but in the Aguator also, by the shade of Extuberancy, which performs the observations above mentioned; and thus by the very same shade you find not only what Reople see the Eclipse, either in whole or in part, (as we now told you) but at what hour it appears to each of them, and how. long; as also the Duration of her Decrease and Encrease in. light, together with the time of her total Obscurity; moreover, this very shade gives you her Height and Azimuth all along, as

*Vid.Op. 1. & you may fee in the * Operations that concern them. B. . 242.49,

> TY LACE year Globe on a Meriai or Line, or otherwise Compofe if, and when you percieve the Moon to begin to correr into the shade of the Earth, consider (as you do when you dek by the *Sank Rays where 'tis day and night) what turn of the 18 9 Maniested, and what nor; for, fince the angeneral of

Courties that libra the Kight, and is aid from thate in the

OPERATION XIII.

To represent the several Phases or Shapes of the Moon by

HIS is rather a Speculation than an Operation, Nor should I have mentioned it, were it not that several (who know something in Mathematics) cannot comprehend the Cause of the Moon's continual Metamorphosis or Change, that is to fay, why she should be now more, now less illuminated, and that also in so different a shape and manner. To comprehend: therefore this, Expose your Globe (elevated on a Stand or a Table as high as your Eye) to the Sun or Moon, and place your felf so before it as to see the whole illuminated half; for (as to sense) the illuminated and shady parts of all Spheres are (as we formerly mentioned) equal. Having then a while confider'd this great Circle made by the Limb or Extremity of the illumination, remove your station a little on the one fide (as for Example towards the right hand) and you will find the illuminated part to appear Gibbons or Oval, I mean not so broad as long, because so much of it is hid from you, as you can now discover of obscurity. From hence go yet farther side-wife, and the visible part of the Globe will be Dicotomous, or party per pale, that is to fay the light and shade will become equal.

After this make another Proportionable step, and all that is illuminated will appear Horned or Lunular, and the obscure part Gibbons; But if you remove to the point opposite to your first Station, you will see nothing besides a dark and shadow'd Hemisphere; whereas should you proceed surther in the same Order, you would perceive Light on the other side, first Lunular, then Dicotomous, next Gibbons, and lastly totally predomular,

minant.

Now as the Globe is always half illuminated, whether we fee little or much of the illumination, so it happens with the Moon, who being in Conjunction appears all dark to us, because her illuminated half is towards the Sun, and opposite to us, but as soon as she gets from him, and consequently is no longer in the same Plane with him and our Eye, we must needs

have:

have a view of some part of the Illumination, seeing she can only appear wholly obscure when she is thus before the Sun. The said Illumination also (since she is Spherical) must seem as on the Globe the more Horned the less it is, and then blunter and blunter according to her Encrease or Elongation, till at last she becomes Dicotomom, afterwards Gibbom, and lastly Full; for by being at her greatest distance from the Sun, or in Opposition with him (which causes our Eye to be in the middle or between them) 'tis impossible she should appear otherwise than all Light: And here you may be pleased to take notice, that if you compass your Globe with a String or Threat that passes throu' the Zenith and Nadir, and let one half of the describ'd Circle represent the Illumination and the other the Obscurity, you may perform this Operation at any time, whether the aforesaid Luminaries shine or no.

A Corollary.

How easy therefore is it to conceive the whole Mistery of the Moons sour principal Changes, and what men mean by them. For first we see that as She is call'd New by an Astronomer from her being with the Sun, (i.e. as fully between our Eye and the Sun, as her then Course permits) so no sooner bas he found by their several motions that she is gotten 90 Degrees or six hours from the Sun, but he says, she is in her first Quarter; and when they are as funder 180 Degrees or 12 Hours (to wit as far as ever they can be) that she is Full; and lastly, as soon as they are distant 270 Degrees or 18 hours on the same side, and 90 Degrees or six hours on the other, that she is in her last quarter; so that at their next meeting she becomes New again.

OPERATION XIV.

How to find how long the Moon wants of any Change, or Cardinal Point, and consequently how old she is.

Propose not this Operaton as a thing exact, but seeing it is a Corollary of the former, I thought sit to hint it; therefore pray take it for better, for worse, and make of it what you can: To resolve then these Questions by the Globe, you are to expose it as before to the Moon when she shines, and move about it till you can there just describe her shape; and by the way you will come

come nearer the mark, if you only consider the Lunular or lesser Portion, whether it happen to be the obscure or the illuminated part of her whole Difens or Orbe; I fay, describe her Shape on the Globe, as neer as you can, and observe how many Degrees the breadth of the Horn'd or Lunular Portion will be in any great Circle, that crosses it in the middle at Right Angles, and that will give you taliter qualiter what you feek

for, as appears more clearly by the enfuing Example.

Having observ'd, suppose, the illuminated Portion of the An Example. Moon to be Lunular, expose your Globe, and move about it 'till you perceive on it an illuminated Lunula proportionable to the Real one, then finding its measure by some great Circle that crosses it at right Angles, to be 40 Degrees, these consequences will follow. First if the Moon be in her Encrease, she is past being New 40 Degrees, i.e. three days and about feven hours, feeing her hourly Elongation from the Sun (is one time with another) about half a Degree and half a minute; but if she be in her Decrease, she wants so many days and hours from being again New. In the next Place it will happen that the obscure partiof the Globe is 140. Degrees broad; for (both parts. or portions making up the apparent Hemisphere) the said obscur'd Part becomes the supplement of the former 40 Degrees; to that 140' amounting to about 279 hours, or 11 days and 15 hours, you may conclude that if the be Encreasing, the wants. so much of being Full, as also that she is 50 Degrees or almost 100 hours (i. e. four Days and almost four hours) past her first Quarter; whereas if she be Decreasing, she will want eleven Days and fifteen hours from her next Conjunction, and be four days and almost 4 hours beyond her last Quarter.

As for knowing the Moons state in relation to her Waxing and Waining, you need only observe on what side of her Discus her illuminated Part stands; sor if it be on the West side of it, the is in a Waxing Condition, if on the East-side in a Waining or Declining one: And here also remember that as to the measuring the aforesaid Portions of the Moons Discus, reprefented on your Globe, you may do it by the Horizon, if she illuminates not much beyond the Zenith, or by the Equator, when the illumination reaches to the Pole or neer it, or by the Ecliptic when it extends it felf a good way further; for the faid Portion of the Moons Discus is measur'd at first fight by that greate

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great Circle which lies equally distant from each Horn of the Lnnula on the Globe, i.e. by that great Circle which crosses it (as we said) in the middle at Right Angles; and when no great Circle does so. you had best measure it exactly with your Compasses, seeing that on the knowledge of its breadth, the Resolution of all the former Questions depend. Many things of great use may be drawn from knowing the true proportion of the illuminated and obscure parts of the Moons Orb, but this I leave to them that have exacter Instruments than the Globe, and more time to make Deductions.

The END of the Third Section.

SECT. IV.

Shewing the Proportion between Perpendiculars and their Shades.

Steing there is the same proportion between all Shades and their Perpendiculars, at least to sense, and seeing the several Almucantars of the two great Luminaries are the chief Cause of the lengthning or shortning of them, I have here adjoin'd a sew by-Operations even in Altimetry it self, as belonging naturally to our Globe, since it not only shows us several ways of finding from time to time the said Almucantars, but gives us also at the same instant without trouble (as appears by the ensuing Operations) the above-mentioned Proportion, and consequently the height of all things Perpendicular to the Hoirizon.

OPERATION I.

How to find the Proportion between the Perpendicular and its Shade.

Onfider the Northern or back part of the Globes Meridian, which we will call hereafter the Quadrant of Proportion, and which is not only devided like the Southern or fore-part into Degrees, but markt also (in relation to the affair in hand,) with feveral Figures, of which that next the Zenith is 17, and the remotest 188. And by the way you must take notice, that when you see a Cross behind any Figure, it signifies half an In- A memoranteger more, so that 17 + is 17 Degrees and a half, 26 + is 26 and dum. a half, &c. When you would therefore Operate, Turn the Southern or fore-part of the Meridian towards the Sun, 'till they be both in the same Plane, i. e. 'till the shade of the Pin in the Zenith falls directly upon the Quadrant of Proportion, and what Figure soever, (suppose 25) the Shade of Extuberancy cuts, that will be the then Proportion between Perpendiculars and their Shades; for here you may take notice, that we ever suppose the Shade to be 100. Nay, if finding (by any of the * former ways) the Sun's height to be (suppose) 14 Degrees, * Sect. 1. Op. you rectify your Bead to 76 Degrees, or the Complement of it, 2. p. 5. you need only clap back your String, that is to fay, draw it from the Zenith, over the Devisions of the afore-mention'd Quadrant, and then the Figures under the Bead (to wit 25) will shew you the required Proportion; In short, take but the Suns Height (any how) and reckon from the Zenith as many Degrees on your said Quadrant of Proportion, and the Figures at the end of your Account will give the Proportion fought for. Now if the Shade of Extuberancy, or the Bead marks not even Degrees for the Sun's Height, but (for Examples sake) 13.30', and consequently salls between the Figures of 23 and 25 in the Quadrant of Proportion, you had best (to avoid all Calculation and Allowance) expect a Moment longer, for then the Sun's Height being even, and without Fraction, you may operate as before. OPE-

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OPERATION IL

How to find the height of a Tower by the Globe.

THIS Operation appears at first Sight to be a Corollary of the former, for finding, as I showd you, that the Shade of Extuberancy salls in the Quadrant of Proportion, on the number (v.g.) 25, and that the said number represents a Perpendicular, do but measure the shade of any Tower and you will soon have its height, seeing that as 100 is to 25 (i.e. as 100 is to the number sound on the said Quadrant) so is the Shade of the Tower, (which being measur'd wee'l suppose 80 yards long) to a fourth number, viz. to 20 the required height.

OPERATION III.

How by the help of your Globe to measure any Tower or height, and yet not to seem to use any Instrument in the operation.

THIS Operation may perchance a little surprise some, and yet it differs not in reality from the former; that thowing you how to measure a beight by your Globe upon the place, and this how to do it privately. To perform then the Operation, you must choose (when you are alone) any of the aforesaid Numbers, on the Quadrant of Proportion, as suppose 25, and feeing that belongs to the 14th. Degree from the Zenith, reclify your Bead to the Complement, i. e. to the 76th from the Zenith in the said Quadrant; this being done move your String hanging on the Zenith's Pin, till your Bead touches the Parallel of the Day, which we now suppose to be the tenth of Mar, and the Hour-Circle, that meets with it there (to wit that of fix in the morning, or fix in the afternoon) tells you that at those hours, on that day of the Month, the perpendicular will be the fourth part of the Shade, i. e. as twenty five to an hundred, so that having discours'd with some body of the possibili-

ty of measuring beights without an Instrument, repair with him to any convenient place, about the foresaid times of the day. and when you find by your Watch that 'tis exactly fix, do but measure the Shade and you will have the required height. And by the way take notice, that as it is in your power to choose what proportion you please, and the more odd and exotic it happens (if you can quickly reduce it) the better it is, for then People will not perchance to foon comprehend the Operation . I far, as you can choose your Proportion, so you may choose the Hour also, for if your Bead be rectify'd to the chosen Proportion, according to the foregoing Example and Instructions, and brought to the hour pitcht upon (suppose 3 in the afternoon) the Parallel, (to wit, that of the fifth of February,) which meets with the the said Bead and Hour-Circle, tells you that then the Proportion will thus happen; nay, you may choose what day and hour you please, if you will be content with the casual Proportion or number which the Bead, when rectify'd (as we mentioned) falls upon.

OPERATION IV.

How to find the Hour by your Stick.

OUR Stick being divided into ten equal parts, and each part by Pricks into as many equal Subdevisions, you must operate thus. Rectify your Bead (on the tenth v.g. of April) to the Sun's Meridian Altitude, and if you then move your String on the Pin of the Zenith, to the Quadrant of Proportion, the Bead will lye (for Example) on 87, fo that having writ this on Paper with the figures of 12 above it, draw your String from the Zenith over the next Hour-Circle on which hand you please. I mean either over that of 11. or 1. and where your String cuts it on the faid Parallel of the day, there place your Bead, and 'twill lye (v. g.) on 93 in the faid Quardrant of Proportion; noting then 93 in your paper under the hours of 11. and 1. proceed then in this manner from Hour-Circle to Hour-Circle, 'till you come to 6, for after the Sun is within an hour of his Rifing or Setting, you may eafily guess what time of Day'tis; besides shadows are then so long that they are troublesome to measure;

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I say proceed in this manner to 6, and a Table like that in the

* 1. 2. 3. 4. 6. * Margin will show you the hour

12. 11. 10. 9. 8. 7. 6. not only during that day, but du
13. 11. 10. 140. 200. 300. 625: out any considerable Errors, for you have nothing to do but to erect your Stick, as perpendicularly as you can, and to measure its Shade with it, so that sinding the length of the said Shade to be, suppose 200 i. e. twice as long as the Stick, your Paper will tell you, that when this proportion happens, 'tis either eight in the morning, or four in the afternoon.

OPERATION. V.

How to take an Angle in Altimetry by the Globe.

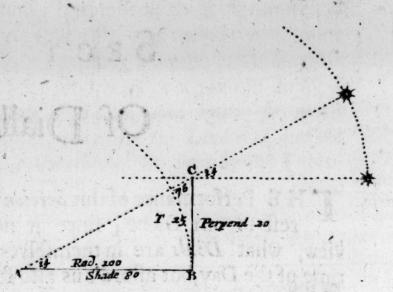
THIS Operation is to be perform'd like that of finding the height of the Sun and Moon, when they shine not out, *Op.2. Sett. as I formerly * show'd you; that is to say, you must place your 1. pag. 6. Globe Horizontal, and having turned the Meridian towards the Tower, move your Eye along the said Meridian, till the Extuberancy of the Globe permits you only to see the top of the Tower, and then bring but your String, (which we suppose you hold in both hands cross the Meridian) towards you, 'till it just takes away the sight of the said Top, and the Degree which your String then lies on, (counting from the Zenith) is that of the required Angle, to wit, of the Angle which is ordinarily taken by any Quadrant, facobs Staff, &c.

OPERATION VI.

How to make and figure the Quadrant of Proportion, as also the Demonstration of the foregoing Operations.

I T appears plainly by the Scheme here before us, that the Shade (AB) being Radius, the Perpendicular (CB) is Tangent of (Av. g. 14.) the Degrees of the Suns height, as also that the Perpendicular (CB) being Radius, the Shade (AB) is Tangent of the

the said height; therefore if the Radius being 100, you mark from the Zenith to the Horizon each Degree of your Quadrant of Proportion with Figures according to the value of their respective Tangents, you must necessarily perform the late Operations, that give us the height of



things, the hour of the Day, &c. For if your Bead be rectify'd (from the Horizon of your Globe) to (76) the Complement of the Suns height, it will be distant from the Zenith just as many Degrees as the Sun is high, to wit 14, and consequently being moved to the Quadrant of Proportion (which is figur'd we see, from the Zenith downwards) must lye there on 25, the Tangent of his said Height, therefore as the Radius 100 is to (25) this Tangent, so (80) the length of the Shade must be to

the Perpendicular 20.

In the next Place if your Bead be restify'd every hour to the Suns height, it must (when moved to the Quadrant) still lye on Tangent Complement of his said hourly height; Now the Shade being always as I told you the Tangent Complement of this height, the former little Tables must needs shew you the corresponding Hour, when we once know the value of the Shade, i.e. its proportion to the Stick. To conclude the Tangents of the sirst 10 Degrees are not express on the Quadrant, because when the Sun is no higher, we may easily guess at the hour, and besides (as we said) the Shade is then extremely long, and consequently very troublesom to measure; nor need we go surther than 62 Degrees, since his greatest Meridian Altitude exceeds not that value.

The End of the Fourth Section.

SECT. V.

Of Dialling.

A preliminary Discourse.

THE Performance of this Section no less appertains than the rest to our Globe; since it not only represents to our view, what Dials are in themselves, and why they shew us the time of the Day, but afford's us also so natural and to easy a way of describing them, that no person can be hardly so ingnorant, who will not (with the least Instruction) in three hours time be able to make one on most Planes, unless perchance for want of a little Digestion and private practice, the Rules shove one another out of his Memory. Nay all the accidental Requisits to Dialling (being these that follow) are here performed without the help of any forrein Instrument.

1. To draw a Meridian Line.

- 2. To draw a Line Parallel to the Horizon on a Plane not Horizontal.
 - 3. To find the Declension of a Plane.
 4. To find how much a Plane Reclines.

5. To find how much a Plane Inclines.

6. To find how long the Sun shines on a Plane; that is to say, when he'l come on, and when He'l go off it, at any time of the year.

* pag 4. + pag. 5. * pag. 10: Besides we have already taught you, how to know when a Plane is * Level, how to find the † Height of the Sun, and how his* Azimuth, all which properly appertain to this Science.

These then are the Operations, I mean by Requisites, which shall be all treated of either immediately before, or immediately after each Dial that requires them. But the I intend to show you, as I now mentioned, this easy and natural way of Dialling, even in what bigness you please without need of Quadrant or Scale of Reduction, without your knowing the least Problem in the Mathematics, or my requiring any thing else of you, that that you can draw a Line from Point to Point, and describe a Circle, when the Radius is given; I say, the I intend this,

yet that you may not be wholly Ignorant of their Geometrical Construction, I shall teach you that also, and therein perchance something both expedite and new; but then I must suppose (for I have not time to instruct you,) that you can Erect a Perpendicular, draw a true Parallel, and know so much of the * Sector as bow (besides the use of the Line of Lines) to Because find the Chord and Sine of any Number of Degrees by it. I men- every body tion the Sector, not that any Ordinary Ruler, with a Line of to know these. Sines, Line of Chords, &c. is unsufficient, but because you have and the folunder the Pedestal of your Globe a Sector to your hand, which lowing Pro-I have order'd there for two Reafons.

First it will be necessary, the Globe standing erect and at perchance at right Angles with the Horizon, to bring the edge of its Pedestal ter's Book, I to your Plane in several Operations; Now seeing this cannot be shall add them. done unless the Pedestal be greater than the Globes Diameter to this Trea-(which would, make it perchance cumbersome, and to take up der will find at too much room) there are therefore under it two small the end of it: wooden Rulers about half an Inch Broad, to flip in, or out to a determin'd length, so that it will be better to have one of them a Sector (which is a very necessary Instrument) than not, especially since 'tis no hindrance to theuse, we chiefly intend it for. Nor would I have any thing more on it (to avoid the Confusion of Devisions) than the Line of Sines on the one side, and the Line of Lines on the other; and as for its length, if it behx inches, it will make an even Foot at full extension, which renders it a very convenient standing measure. My second Reafon for the faid Sector is, because I will show you, how to find by is the TANGENT and SECAN Tof any degree even according to any Radius, and how ufefull an Operation this is (and particularly in Dialing,) every body well knows that has the least inlight in it.

Suppose then you desire the Tangent and Secant of 50 De- How to find? grees; open your Sector, and taking (CR) the given Radius the Tangent between your Compasses, put it over in the Line of Sines, at the and Secant of Sine of 40, viz. at the Complement of the Angle required, and any degree. the distance between the Figures of 50 and 50, will be the Fangent sought for; and the distance between the Figures of 90 and 90 will be the Secant of the said 50 Degrees.

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These two Problems I recommend to you because they are extremly ingenious and useful, found out it seems a while ago

blems) has not bandMr.Gun-

Moxon.

by,

by Mr. Line (the Author of that admirable Horological Pile in White-Hall Garden) as, fince his death, one of his Scholars (that hinted them to me) informed me, and upon confideration I found them exactly true, having thus demonstrated them.

Demon Stra-

Tis evident by Sch. 1. that as the fine Complement A B is to the Sine C B, so the Radius A D is to the Tangent E D. Again 'tis evident by Scheme 2. that as K C: K S:: C R: S T, but by Construction K C is on the Sector the K Sine of 4 or Sine complement of 50, and C S the Sine of 50 it self, therefore C R being the Radius given, S T must be the Tangent requir'd, viz. the Tangent of 50, according to that Radius. On

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Complement AB is to the Radius AD, so is the Radius AC. (or AD) to the Secant AE. Again you see by Scheme second, that KC: KD:: CR: DP; but by construction KC is the Sine of 40 or Sine Complement of 50, and KD is Sine of 90 or Radius of the Sector, and CR is the Radius given, ergo PD must be the Secant required.

Having thus done with the Preliminaries, we'l now come to the business it self, after I have told you there are five principal Planes on which a Dial may be made; to wit the Horizontal, the Vertical, the Declining, the Reclining and the Inclining Plane; and first of the Horizontal, since that Dial is the Basis and Foundation of all the Rest.

OPERATION I.

) Efore you proceed further, you must know Reader, that the Printer A Memoran-D (skipping a line in the last Paragraph, and then adjusting the dum. number of Planes to those he found exprest) has left out two, so that the before mentioned principal Planes are 7; viz. the Horizontal Plane, the Direct Vertical Plane, the Declining Vertical Plane, the Direst Reclining Plane, the Direct Inclining Plane, the Reclining Declining Plane, and the Inclining Declining Plane. First, then of the Horizontal, that Dial being (as is said) the Foundation of this Science, and afterwards of the rest in Order; for the Author treats of all Dials that are to be described on the aforesaid Planes. J.M.

How to describe an Horizontal Dial by the Globe, for the Elevation of London.

The first way.

Pen your Compasses at 60 Degrees in any great Circle The construof your Globe, and draw on a sheet of Paper a blind Stion. Circle with a fair Diameter throu' it, for the Meridian or 12 a Clock hour line of your Dial; Then take with your. Compasses in the Horizon of your said Globe, the several Distances between the next 8 morning or evening hour Circles and its Meridian or ordinary 12 a clock hour Circle, and marking these Distances successively in the blind Circle on both sides of its Diameter, they and the Center will be the Points by which you may draw all hour Lines from 4 in the Morning till 8 at Night; and if you would have a Dial bigger than the blind Circle, draw about it a bigger Circle, if a lesser a less: nay, if you describe any other Figure as an Oval, Square Oblong, &c. the faid Points will as well guide your Ruler, as when the blind Circle it self was the Extremity or border of your Plane. But least this Direction should be too obscure for a Beginner, I will here adjoyn an Example.

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Having opened your Compasses, as I said, at 60 Degrees in An Example. any great Circle of your Globe, and describ'd a blind Circle, to wit, IpTc, as in Scheme third, draw a fair line I T any how throu' the Center O for your Meridian or 12 a clock

hour

hour Line; and by the way remember that in the Fabrique of this Dial you place the point I ever towards you, and T farthest from you, to the end you mistake not when directed to this or that hand. Having then proceeded thus far, put one foot of your Compasses on the Meridian or (according to the Polar Figures) the 12 a clock Circle of your Globe where it cuts the Horizon, and the other foot on the I a Clock Circle, and mark this distance in the blind Circle from I towards the left hand, to wit from I to k, and it will give you a point or mark for your 1 a Clock hour line, and from I to b towards your right hand the mark for your 11 a Clock hour Line. In the next place take in the said Horizon the distance between the I and 2 a Clock Circles, and place it from k onwards to l for a mark for your 2 a Clock Line, and from b to g for the 10 a Clock line, and so on till you come to r, 8 at night, and to a, 4 in the morning, which are the latest and earliest Summer hours. If then you would have a larger Dial describe a larger Circle, suppose, NESW; or if a lesser Dial, a lesser Circle, as MPQR, and laying your Ruler on the Center O, and on each of the former Marks or Letters in the faid blind Circle successively, draw but a fair line to the defigned Limb or Border (whether it be a Circle, or the square V X Y Z or any other Figure,) and your Dial wants nothing bdt a Cock; but remember that you need not draw your bour lines quite from the Center O, because meeting all there, they will be apt to blur; therefore describe about the said Center, at what distance you please, a little Circle (like y A A) and your lines will terminate there with more neatness and How to draw convenience. Now if you have a mind to put on half hours the halfhours, and quarters, you will not much err if you divide each hour quarters,&c. into four parts, but to be exact you must make use of your

String, thus. You know that the distance between each hour-Circle in the Equator is 15 Degrees, Draw therefore your String from the Pole throu the Equator of your Globe, over 7 degrees and 30 minutes, (or half the distance between each Hour Circle) and where the String cuts the Horizon there will be the true half Hour of that Hour; fo that if you mark with your Compasses the said distance on the blind Circle, between the corresponding hour lines, the Ruler (paffing throu' that Nark and Center) will give you in the Border the place of that half hour; and in like manner you are to proceed in marking out the rest, as also the Quarters, and all other Subdivisions.

As for the Stile or Cock of this Dial, it must always at the Center make an Angle with the Meridian or 12 a Clock Line (OI) equal to the Distance between the Pole and the nearest part of the Horizon of the Globe; that is to say an Angle equal to the Elevation or Latitude of the Place; therefore your Dial being made (suppose) for London, open your Compasses at the aforesaid distance, or at 51 Degrees and \(\frac{1}{2} \), and placing one foot on I, the other will fall on K in the said blind Circle; so that drawing the blind line OK to \(\pi_1 \), you will have the Triangle IO \(\pi_2 \), which if you so erect, that the Point O lyes just on the Center, and the Base IO on your 12 a Clock line (or Substile) your Dial is sinished.

And here you may take notice, that the this Stile be the Triangle I O m, yet you may fashion it into what shape you please, in case the side # O (which indicates or shows the Hour) makes still an Angle of 51 Degrees and with the Meridian IO; nay, you may make it a Pin or upright Stile, as appears by the Perpendiculars AB, GH and # I, for either of them will ferve the turn by marking the hour with the shade of its Apex or Top: but then they must not be plac'd in the Center O, but thereon the Substilar, where (falling from the Indicating side On) they stand Perpendicular to it; that is to fay, the Pin AB (being part of the Triangle or Stile I O m) must be erected at B, the Pin G H at H, and Tat I; and the reason, why they perform this Office, as well as the whole Triangle IO m is, because their Tops are parts of the Line O m, which is the only fide of the said Triangle, that shows the Hour, as we mention'd before. Now for the Demonstration of all, it follows in the next Operation.

OPERATION II.

How to describe an Horizontal Dial by the Globe for the Elevation of London.

The fecond way.

Etion.

The Constru- DEscribe a Circle of what bigness you please, and draw a Meridian, or 12 a Clock line throu'it, as before; then count in the Horizon of your Globe how many Degrees there are between the Hour-Circles of 12 and 1, or, (which is the same thing) between 12 and 11, and you will find their number to be about 11. 40'. These place on both sides of your said Meridian Line by the help of a Quadrant, or Line of Chords, and they'l give you (if you lay your Ruler as before on the Center) the II and I a Clock Hour Lines of your Dial, to wit, the distance from I to k, and from I to b, as may be seen in the aforesaid third Scheme. Proceed then in this manner as to the rest of the Hour lines, and for your Stile and Substilar, the former Directions are sufficient.

Demonstration.

The Demonstration or Reason why these Dials show the Hour is not difficult; for if you confider your Globe, you will see that all its Hour Circles are equally distant from each other, and that the Axis of the World (of which the two Poles are the extremities) lies in the middle of them, and is in truth a part of each, as being the common Section of them all; therefore when the Sun comes into the Plane of any Hour Circle (for example to that of 4 in the morning) the shade of that Hour-Circle will fall there, where the faid Hour Circle cuts the Horizon on the Opposite or Western side, and confequently the Axis being in that Plane, as a part of it, its Shade must needs fall there also. Now fince the Blind Circle or Limb of the Dial described is a Circle representing the Horizon, and having by Construction its Hour-lines distant from each other as the Hour Circles of the Globe or World are distant in their Horizons, and since the Hour-lines of This (and consequently of all other Dials) are only the intersections of the Hour-Circles with their respective Planes, it must needs follow, if we place in the middle of the said Dial a Cock or Stile, making an Angle of 51, 30, with its Meridian line or Substilar (to wit, the Angle which the Axis of the World makes with the intersection of the Meridian and Plane of the Horizon) 'twill cast a Shade directly on the Hour line corresponding to the Hour Circle in whose Flane the Sun then lies, in case the Meridian or 12 a Clock line of the Dial be plac't North and South, like the Meridian of the Globe when compos'd; for the Globe it self without it be compos'd will not (as we have formerly mention'd) shew the Hour, because its Hour-Circles do not then correspond with the Heavenly ones. And as for the reason why the 12 a Clock line is the Substilar, 'tis because the true Height of the Axis above the Plane (which the Stile or Cock, as I showd you, represents) is to be measured in the Hour Circle that falls on the Plane at right Angles, which being the Meridian or ordinary 12 a Clock Hour Circle, it follows that its Intersection with the Plane must be the Substilar, or Line with which the Stile is to make the Angle of the Elevation.

All that we have then said of this Dial may be clearly seen by Sch. 5. which represents your Globe cut into an Horizontal Plane, with its Dial on it, as Sch. 4. does the Globe entire, when you consider it in the description of the said Dials for there you have before your eyes (by the Letters I k l, &c.) not only how to open your Compasses from Hour-Circle to Hour Circle for the true placing the Distances of each Hour-Line on your blind Circle, but also the number of Degrees in the Horizon between every Hour Circle and the Meridian. Besides, by the Horizons oblique cutting the Hour Circles, you may see how that (notwithstanding the equality of the Suns Horary motion) the Hour-lines of this Dial must be unequal, and consequently that they are of different distances in diffe-

rent Latitudes.

OPERATION III.

To describe an Herizontal Dial Geometrically, for the Elevation of London.

Escribe a fair Circle as ABCD, and if you would have your Dial of another Shape, you may afterwards describe about it what Figure you please; I say, describe the fair Circle ABCD, and draw throu' its Center O the Line AOC for yout Meridian or 12 a Clock hour line, and croffing it at right angles with BD for the Morning and Evening 6 a Clock hour lines, mark in it (by the help of your Line of Sines or any way else) from A the value of 51.30. or Latitude of your dwelling, which happening to reach, (for example fake) to K, draw the blind line OK; then throu'any point of A O(suppose A) draw G H, another blind line, parallel to B D, or at right Angles with the faid A O, and taking with your Compasses the nearest distance between A and OK, which being (suppose) the point L, let AL, by the help of your Sector (according to our former * directions,) be the Radius to the Tangent Line GH; so that marking in it on both fides of A, the Tangents of 15, 30, 45, 60, and 75 Degrees, the faid Center O and the point 15 will give you the Hour-lines of 1 and 11, the Center O and 30, those of 2 and 10, and in this manner proceed to 75, which will give you the Hourlines of 5 and 7; and as for those beyond the 6 a Clock lines, do but produce 8 in the Morning, and 'twill give you 8 at Night, and 7 in the Morning 7 at Night, as will 4 and 5 in the Evening, the like forenoon Hours.

Thus then you have not only an Horizontal Dial Geometrically described, almost as soon as the former, (and this without embroyling the Plane with multiplicity of blind Circles and Lines) but a way also (in case you have no Sector) how to make any Tangent Line serve your turn; for, 'tis but taking between the Compasses 45 Degrees of it (i.e. a distance equal to its Radius) and finding out (by a trial or two) the Point

* pag. 71.

(fup;

(suppose) R in the line O A, where one foot of your Compasses being placed, the other just touches M (the suppos'd nearest point or distance in O K from the said R) draw throu' R a line at right Angles with the Meridian, and noting in it, as we show'd you before, the Degrees of each hour (according to this new Tangent line) the Center O and these Degrees will give you the points of each hour line; for as the former Radius A L was to the several Degrees in its Tangent Line, so will the now Radius R M be to the several Degrees in its Tangent Line.

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As for the Demonstration or Reason of this Dial, every body The Demonthat understands Gnomonics comprehends it, I doubt not, at the stration. first fight; for the Angle O in the Triangle K O A, being by construction equal to the Elevation, do but place the Base A Oon a Meridian Line, and if you consider the Side K O as the Indicating Side of the Stile or Cock, it necessarily follows, that it will represent the Axis of the World; for it is evident that its Top K. will point directly to the Pole, and touch it, if produc'd, whilit O its other extremity passes throu' the Center of the Horizontal Flane; therefore if a Circle (whose Radius is A L) were so plac't on this Stile or Axis, that its Diameter croft it at right Angles. at L, the faid Circle would represent Circulum maximum semper apparentium, for that Circle in the Heavens ever touches the Horizon, as this would do at A. This Circle then being parallel to the Equator, is divided by the Hour Circles into twenty four equal parts, and confequently each fifteen Degrees in its Tangent Line GH, will correspond with its said equal parts or Divisions. Now GH is also the Tangent Line of the Horizon, as touching it in the Point A, but where the Hour Circles cut the Horizon, or its Tangent line, there the Points will be, to which (from the Center) the Hour Lines in an Horizontal Dial are to be drawn; ergo O the Center of your Horizontal Plane, and the several fisteen Degrees in the common Tangent G Hare the true points of the Hour Lines. Besides as the distance between each Hour Line (if A L, be the Radius) is 15 Degrees, so if A Obe Radius (I mean O A the Radius of the Horizontal Plane) the said Hour Lines will be distant as many Degrees afunder, as they are in the Horizon of the World, or as you found them in the Fabrick of the fecond Horizontal Dial by the Globe. Here also you may see, that the true place of this Dial is to be in the Center of the Earth, and not:

not on its superficies, but by reason of the Suns vast distance, the Error, which thereby happens) is not sensible; nay, because the Error is not sensible, we may safely conclude, that the Sun is

So much then for Horizontal Dials, since there now remains

vastly distant from us.

nothing necessary to be known, but how to find whether they stand Level or no (which is handled in the first * Section) and how to draw a Meridian Line for their true placing, which is

A Memorandum.

pag.4.

learnt by the following Operation. But before we go further let me advise you (when soever you make a Dial of consequence, of what kind soever it be) to describe it first on Paper, and thence to mark out the Lines on your real Plane, for thereby you will not only keep your faid Plane neat, and more judiciously chuse the best place for the Center of your Dial, but (besides the several conveniences which practice will show you) the Lines themselves will be more exactly drawn, by reason you can manage your Paper draught as you please.

OPERATION. IV.

How to draw a true meridian Line on any Horizontal Plane.

pag. 8.

Ompose your Globe on the Plane, or Place where your Dial is to stand, and making marks or pricks there (on each fide of the Pedestal) at the Letters S and N, draw but a Line throu' those marks, and that will be a true Meridian Line, and if you do the like under the Letters E and W, you will have a true East and West Line.

OFERATION. V.

How to Describe a Vertical, or an Erect Direct South Dial by your Globe for the Elevation of London.

The first way.

HIS Dial is made on the Plane of the Primary Vertical, which passes from the Zenith to the Nadir throu the East and West points, and being therefore erect, and facing also directly the South, tis commonly called an Erett Direct South Dial; fo that if you draw but your String from the Zenith to the Nadir thro either of the Intersections of the Horizon with the Equator, 'twill appear upon the Superficies of the Globe, like the emerging edge of a thin Plate, and consequently represent the said Plane, or at least as much of it as is requisite.

This being done, open your Compasses at 60 Degrees, as * be- The Construfore, and describe on a sheet of paper the blind Semi-Circle I tion. PC (as in Scheme 10) with the Diamiter or Meridian IOT throu' it, then take with your Compasses the distance between the Zenith of your Globe, and the Intersection of your String with the nearest Hour Circle, and 'twill in your Blind Circle on both sides of the Meridian or twelve a Clock Line, (to wit from I to k, and I to b) give you marks, by which you may draw from the Center O the Hour Lines of 1 and 11; as will the distance from k to 1, and b to g (viz. the distance from the said first Intersection to the second) the marks of 2 and 10; and in this manner you must proceed to 6 and 6, as the latest and earlieft hours, that this kind of Dial shows; for since its Sides lye full East and West, and that the Sun never comes to the East before 6 in the morning, nor is later in the West than 6 at night, 'tis impossible that the Plane should significantly contain more Hour-Lines. And as for the Stile or Cock, the distance on your Globe between the Zenith and the Pole (being the Complement of the Elevation) gives you from I to K the Degrees of its height above the Plane, so that you may easily place and erect it, the Substile being still the Meridian. The Rules in the first Horizontal Dial will show you also both how to contract and enlarge it, and how to refolve (especially if you consult the 7th. 8th. and 10th. Schemes) any difficulty that can possibly arise in the present Operation; for Scheme the 7th. shows you the Globe it felf with the String drawn from the Zenith to the Nadir throu' the East Intersection of the Aquator with the Horizon: and Scheme the 8th. the Globe cut into this Plane by the said String, and lastly the lower part of Scheme the 10th. (to wit, the Semi-Circle PIC) the Dial described by the foregoing Directi-Now for the Demonstration it follows in the 8th. Operation.

OPERATION VI.

How to make this Vertical South Dial by the Globe for the Elvation of London.

The fecond Way.

The construation.

Escribe a Blinde Circle of what bigness you please with a Diameter throu' it, and placing your String on the East orw ft Poynt of the Globe as before, measure (by your Beador Compasses in any great Circle) the distance between the Zenith and each Intersection of the said String with the Hour Circles, and you will have the Degrees of every Hour from 12 a Clock, as the before mentioned Seventh Scheme shows you; so that by the help of your Sector (or of any Line of Chords or Quadrant) you may mark them successively in your Rlind Circle on both fides of the Diameter, and then if you draw from the Center Lines throu' those marks, your Dial is finish't; for as to the Stile and Substilar, you need no other Instruction than what you had in the last Operation, which also directs you to the Demonfration, fince the same serves both.

OPERATION. VII.

How to draw a Line Parallel to the Horizon; together with two ways bow to place truly all paper Draughts on their respective Plane.

pag. 79. How to draw how to place truly the draught on its Plane

Aving lately advised you To Delineate all Dials on * Paper, before you draw them on your designed Plane, and having show'd you how to describe this Dial, 'tis now time to teach a Line Para- you how to draw an Horizontal Line on this Plane, that you lel to the Ho- may thereby truly place your Draughts. Slip therefore out rizon, and your two Rulers, which are under the the Pedestal (as I already mentioned) and placing the end of one on a convenient Center (chosen by you) in your Plane, you'l have by the end of the other (when the Plummet falls on the Afterisk or little Star) a fe-

cond Point, and consequently marks to draw the required line by; so that if you then place the Center of your said Draught on the Center of the Plane, and its 6 a Clock Hour Line on your Horizontal Line, all the other Lines will fall on their true places, and thereby show you where (with a Cole or the like) to mark out points for the perfect and final drawing of them. The Cock also of the Paper Dial, will direct you in the placing of the other; for they are both to be of the same height above their respective Planes, with their Tops pointing the same way; viz. downwards to the Horizon in all these South Dials.

But if you will have yet a more easy way of placing a Paper An easier way Draught not only on this, but on any Plane for which 'tis made, how to place look what a Clock 'tis by your Globe, and moving your faid draught on Draught on its Plane 'till it shows exactly the true Hour, do its Plane. but fix it there, and you may mark out the Points for your fair Lines with all the ease imaginable.

OPERATION. VIII.

How to make a Vertical or Erect Direct North Dial for the Elevation of London.

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HERE is no difference between the Fabrick of this Dial and the former, unless it be in figuring it; for a South Dial reverst is a North Dial, the After-noon Hour Lines being mark't with the Morning Figures, and the Morning ones with those of the Asternoon; So that the Top of the Stile points now upwards, as may be feen by Scheme 9th, and by the upper part of Scheme 1 oth. to wit, by the Semi Circle P T C; therefore when you chuse a Center in your design'd or real Plane for this Dial, let it be in the lower part of it to have Room for the Hour Lines to run upwards.

And by the way you must here remember, that the'I bad you in the making of this your Vretical South Dial, to take the distance between the Zenith and the Intersection of the String with the next Hour Circle for the 1 and 11 a Clock Hour Lines, &c, yet that Section of your Globe by your String from the Zenith as aforefaid, gives in truth a North Dial, and therefore in strictness you ought to have taken the Distance between the

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Nadir and the several Intersections of the Plane with the Hour-Circles; but since both Dials are (as I told you) alike, 'tis best always to operate thus from the Zenith, as being more at hand than the Nadir, and consequently more convenient.

Demonstrati-

The Demonstration or reason why these Dials show the Hour, differs even at first Conception but little, and at the fecond not at all from that already given for the Horizontal Dial. By the first Conception I mean our considering these Planes as Vertical and Erect; for fince, the Hour-lines of all Dials are (as I show'd you in the former Demonstration) the Intersections only of the respective Hour-Circles with the Planes, and fince the hourly indicating Shade, is the Shade of the Axis or of the Hour-Circle, which then lies in the Plane of the Sun, it must follow, that the Mark made (for example fake) by the 4 a Clock Morning Hour Circle on the String, and the Center of the faid Plane (which is the common passage of all the Hour-Circles) will be two true Marks or Points for you to draw that hour-Line by, and confequently that the Shade of the Axis will still fall on the faid hour-line as often as the Sun comes into the Plane of that Hour-Circle. Now your blind Circle is (by construction) equal to the Circle made by the String on the Globe, and the Marks on its Limb are equal to the Marks on the faid String, therefore the Dial must be truly drawn, and the Stile plac't on the 12 a Clock line (to wit on the intersection of that Hour-Circle, which falls on the Plane at right Angles) must truly cast its shade from time to time, seeing by its Site and Angle it corresponds with the Axis of the World. As for our second Conception in reference to these Dials, we shall find by it that their Planes are real Horizontal ones to some People or other; for this Section of the Globe being a great Circle will be the Horizon to those that live in the Pole of it, viz. to those under our Meridian 90 Degrees from our Zenith, which being a point in our Horizon, makes their Horizontal Dials always our Direct Vertical ones, and their Direct Vertical Dials our Horizontal ones. 'Tis plain then, that the present Dials are exactly describ'd, if our former Directions and Proof of an Horizontal one be true; for all the Hour Lines are here drawn from the Center to the several intersections of the Hour-Circles and Horizon, which (as we

are to suppose) the String represents. Nor do's the Cock of these Dials dister from the former Rules; for having the Meridian or 12 a Clock line for Substilar for the sormer reason, and being 38 Degrees and a half above it, it makes an Angle equal to the Elevation of the People, who have the said Plane for Horizon.

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OPERATION IX.

To make the aforesaid North and South Dials Geometrically, for the Elevation of London.

There is no need of a Scheme for this Operation, since 'tis a Corollary from what we have now said; for make becan Horizontal Dial Geometrically (as we formerly show'd you in Scheme the 6th) according to the Complement of the Elevation of your Place, and that will serve (the figuring only confider'd) for either Dial.

Here then you may see that OS, or ON the Basis or Foot of the Stile of these Dials, (that is to say, the distance between its Center and its Horizontal edge or side) is ever the Tangent of the Elevation; for tis the Tangent Complement of FS or NR the Stiles height above the Plane. And here also you see that the very same Dial (the sigures only transpos'd) will serve both for an Horizontal and this Direct Vertical one to those that live in the Latitude of 45 Degrees, since the Elevation of the Pole and Complement of it is there the same.

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OPERATION X.

To describe by the Globe, Meridian Dials, or (as others call them) East or West Dials for the Elevation of London.

These Dials the Vertical and Direct (as passing thre our Zenith, and sacing also two Cardinal Points or Quarters of the World) are very different from the sormer, nor has any body (I believe) taught yet their Description by the Globe.

To perform therefore this Operation, you must by the help some few of premis'd.

of your String or Compasses describe on your Globe, with Chalk (or the like matter) an Arch (as in Sch. 11.) which having its Pole at K (the East-point, for examples fake, of the Aquinoctial) cuts somewhere or other the 11 a Clock Northern hour Circle, I mean the II a Clock hour Circle on the Northern, or black part of the Globe; and this Arch by reaching from the point C in the Aquinostial Colure (or 6 a Clock Circle) to Hin the Horizon on the said Northern side of the Globe, will be a piece of a little Circle parallel to the Meridian containing the Degrees of the Elevation of the Pole, and cutting all the Hour-Circles also from 6 to 11. But if this be thought too troublesom a work, the Globe-maker may avoid it by putting 6 Pricks or Afterisks upon the Globe, where the faid Arch and Hour-Circles would interfect, as may be seen in the said 11 Scheme at C, O, S, T, V and Z; so that if beyond C he adds one prick more, viz. at R, to give you from H the Radius, or 60 Degrees of the said Arch, you need nothing elfe.

This being premis'd, describe on a sheet of paper (HR,

The Constru-East Dial.

or 60 degrees of the said Arch being Radius) a blind Circle ction of an as in Sch. 12, and drawing the Line Hh how you please throu' K its Center to represent the intersection of the Horizon, open your Compasses to the said Arches full extent, to wit, from H to C, and putting one foot on the blind Circle at H, and the other marking there at C, draw the line PC m throu's the Center K, and 'twill represent the intersection of the Aquinoctial Colure (or 6 a Clock hour Circle) with your said blind Circle or Plane; so that if you take from off your Globe, the distances between the point C, and the several Intersections of the Hour Circles with the said Arch C H, and place them on your blind Circle on the right hand fide of PC , as well below the Horizon Hh, as above it, and draw lines thro' them (viz. O o, So, Tr, Vu, and Z) you will have a compleat East Dial describ'd, after you have drawn 2 lines more on the left side of the said P C n, to wit, the Line N v distant from it as is Oo, and the Line Mu, as is So. As for the figuring each hour line, it must be according to the Figures of the corresponding Hour-Circles cut by the aforesaid Arch CH, and thus you will find them figured in the forementioned Scheme 12, which thews you too how the Borders or Parallels are drawn for the faid Figures to lye in, as being only double

double Lines (equidiftant at pleasure) on both sides of the Horizon Hh; and here also by the blind Lines, and by the fair ones, you have before your Eyes what is necessary to be exprest on your fair Plane, and what not.

Nor is there any difference in the Construction of a West- Of a West Dial, except it be in turning on your draught the Hour-Lines or Parallels the other way, to the end they may all point Northwards on their respective Planes; for thus (in Sch. 11.) do the Prick Lines (m 8, n 7, c 6, 05, s 4, t 3, u 2 and z 1.) which would truly represent this Dial, if they were produced in the faid Scheme.

Now for the Substilar tis the 6 a Clock Hour Line, since that of the Stile Hour Circle salls on the Plane at right Angles, and as for the and Substilar. Cock it may be a Gallows Stile (as in Scheme 13) or a Pin (as

in Scheme 14) so it be plac't on the Substilar and perpendicular to it, having its height equal to the Distance between the Pricks or Afterisks Cand P in the said II Scheme, or (which is all one) to the distance between K and X. viz. the nearest distance between the Substilar, and the 9 a Clock hour line in an East-Dial, and the Substilar and the 3 a Clock-Line in a West Dial.

But here you are to remember, that when I say, that the height of the Stile is to be equal to the distance between C and P. I mean in rigour equal to the Sine, and not the Chord of that Arch; but seeing the Chord of 10 Degrees, differs not sensibly from the Sine (and by the way the Arch C P on the Globe will not be above 10 Degrees from the Meridian,) the interval between C and P will serve the Turn. But if you would be more exact take between your Compasses the distance of double CP, to wit the interval of (suppose) 20 degrees, and half of it is the required distance; for half the Chord of 20 Deg. is equal to the Sine of 10. Or if you, please you may erect a needle at C Paralel to P (the elevated Pole of the Globe) and the distance between them will be the true Height of your Stile. To Conclude, You may contract and enlarge these Dials as you please, by drawing the hour lines twice or thrice (or according to any other proportion) nearer or farther afunder, and so abateing or heightning in the like manner your Stile.

The Demonstration is obvious, for fince the points M, N,C,O, The Demon. S, T, V and Z in the upper part of the blindCircle or Plane, and the Points $\mu, \nu, \pi, o, \sigma, \tau, s$. (. on the lower part of it are (by being equal in distance to those on the Arch) the intersections of

the morning hour Circles of 4, 5, 6, 7, 8, 9, 10, 11. With the edges of the said Plane, it follows that the Lines drawn from the corresponding Points, must be the true hour lines of this Dial, since the hour Lines (as we said) of all Dials, are only the Intersections of the respective hour Circles with the Plane. Again the shade of the Axis (the Axis being a part of all the hour Circles) falls ever on the Hour-Line or Intersection of this or that Hour Circle, as often as the Sun comes into the Plane of that Hour-Circle, therefore the Stile of this Dial representing truly the Axis (since tis above the Plane, and distant from it as 'tis on the Globe) will cast its Shade every hour on the corresponding hour Line; and as for the reason, why the height of the said Axis is equal to the distance between the 3 or 9 a Clock Lines and the Substilar, it shall be shown in the Demonstration of the next Operation.

OPERATION XII.

How to describe an East or West Dial Geometrically for the Elevation of London.

The Constru-

RAW the blind Line H h and cross it from your left hand (as in Sch. 13.) with Æ a another blind-line to make an Angle at their Intersection K equal to the Complement of the Elevation, then pricking in the said Line E e on the right side of K, the respective Tangents of 15.30 45.60. and 75 Degrees, as also on the left the Tangents of 15 and 30, Draw but Perpendiculars through the Pricks, and you have an East-Dial; whereas should you cross (as in Sch. 14.) Hb with Æ & from the right hand, and pricking the aforesaid Tangents the other way, draw Perpendiculars through them, you would have a West-Dial. By these Schemes also you may know how each Dial is to be Figur'd, the East-Dial containing (as you see) all the hours from 4 in the morning 'till Noon: and the West all Now for their Cocks, the hours from Noon to 8 at Night. they are (as I said, in the last Operation) to be a Pin, or a Gallowes Stile, and in height equal to the Tangent of 45. Degrees, or distance between the 9 or 3 a Clock hour Lines and that of fix, which is ever their Substilar.

The Demon- These Dials must be true, if their Planes lye in or Parallel stration. to the Meridian; for since the Line Hb, by being plac'd ac-

cording

cording to our Hypothesis berizontal, represents the interfection of the Horizon, and the line E a that of the Aquator, by making an Angle with the faid H b equal to the complement of the Elevation, the substilar must be the Intersection of the EquinoctialColure(or 6 a Clock bour Circle) with the Plane, fince that Hour-Circle falls on the Plane at right Angles. If then a Gallows-Stile be set on the said Substilar and Perpendicular to it, its Shade must needs constantly cross the Aquator A a at right Angles. Now when the Sun is in the Plane of the 6 aclock hour Circle, his Ray makes no Angle with the faid Stile, because the Sun, and the Stile are in the same Plane, and so the Bade falls directly along the Sulftilar; but when he gets (for examples fake) into the next hour Circle, his Ray (the height of the Stile being Radius) makes an Angle of 19 Degrees with the faid Stile, and confequently the distance of the two shades are in the line Æ e the Tangent of those Degrees. The like therefore being said of the next Hour Circle and so on, it follows (as I mention'd in the beginning) that the pricking from the intersection K, the Tangents of 15, 30, 45, 60 and 75 Degrees in the line E a, must give you points to draw the perpendiculars or true bour-lines of this Dial by, as also, that the Tangent of 45 Degrees gives the height of the Stile, fince the Tangent of those Degrees, (which you see gives the 3 and 9 a clock lines) is equal to the Radius.

Here also we see not only why these hour-lines are The reason of so unequally distant, since they are so many Parallels mar- the unequal shall'd according to the Divisions of a Tangent line, but why the distance of 12 a Clock hour line can never be really express'd, for 'tis the these bour-Tangent of 90 Degrees which is infinite.

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OPERATION XIII.

How to describe a Declining Dial by the Globe for the Elevation of London.

The first Way.

THIS Plane (as passing from the Zenith to the Nadir) is What a Dea still Vertical, and should (you may suppose) be by right the clining Plane primary Vertical, but by its tendency towards the East or " West Points, its Dial takes the Appellation of a Declining one,

that is to fay, of a Dial, whose Plane declines so many degrees from facing directly the North and South, as is its tendency to-

wards the faid East or West points.

The Constru-Sion. * pag. 80. To describe bours of a Declining Dial.

As for the way of making this Dial it differs little from the first Direct Erect one, already * treated of; for supposing your present given Plane declines 40 Degrees from full South towards the East, you must draw your String (which ever represents the Morning the Edges, as we have said, of your Plane) not throu' the East Point of the Horizon of your Globe, as before, but throu' 40 Degrees further towards the North, for this makes the String to represent part of a Plane that comes nearer (by so many Degrees) the facing of the East than it did. Then opening your Compasses at 60 Degrees in any of the great Circles, and describing (as in Sch. 17th.) the blind one PZW, prick in it from its Meridian Line OZ, the distance between the Zenith of your Globe and the intersection of your String with the first Hour. Circle (to wit between Z and b in Sch. 15.) and it will give you a mark for the II a Clock line on your Dial; and the distance between the Zenith and the Intersection of your String with the next Hour-Circle(to wit between Z and c) will give you the mark of the 10 a Clock line, and thus you must proceed to every Hour-Circle cut thus by your String, till it falls on the Horizon, that is to fay from z to d, e,f,g, b, letters marking (as you fee in the faid Scheme) the 9,8,7,6,5 and 4 a Clock Hour Circles, and consequently giving you those Hour-lines on your Dial.

To describe the Afternoon Hours.

Dial.

Now for the Afternoon bour lines (which are no longer equal in distance to the Morning ones,) you have nothing to do but to draw your String, on the West fide of your Globe, thron' 40 Degrees in the Horizon the contrary way (viz. from the West towards the South) and the distance between the Zenith and the Point in the first Hour-Circle cut by your String (to wit from Z to kin Sch. 16.) will give you the mark for Ta Clock, and the distance from thence to the next Point of Intersection gives you that of 2, to wit, from Z to 1, and in this Order you are to proceed to n, the 4 a Clock Hour Circle, that is to fay, till you come to the intersection of the String with the Horizon on the Westfide of your Globe.

As for your Stile and Substilar they differ also from those of How to make the Stile and direct North and South Dials; for the faid Stile or Cock is to be Substilar of a no longer placed on the 12 a Clock Line, nor will its height now Declining

be equal to the Complement of your Elevation, therefore having drawn your String throu' the Degrees of Declenfion in the Horizon as before, and putting one foot of your Compasses in the North Pole, find with the other the nearest Point on your String, to wit S (as in Sch. 15.) and the distance between S the faid nearest Point and the Zenith of your Globe will be Z S in the blind Circle of Scheme the 17th, to wit the distance between the Meridian Line of your Dial and your Substilar, which in this our Example lyes from the Meridian towards your left hand or Morning hours, and the distance from the said Point in the String to the Pole (being from S to P) will in the faid blind Circle be the height of your Stile; fo that if you erect and place your faid Stile from the Center all along the Substilar OS it will continually show you the Hour.

But if you fancy that the Extension of your Compasses from A Memoranthe Pole to the String will not give you precisely this Point, since your said Compasses may seem to touch it in several Points; I fay, if you doubt or fancy this, fasten a Thred on the Pole, and drawing it streight over the Horizon at 40 Degrees from the Meridian of your Globe Eastwardly (i.e. till it passes throu' the Pole of the Plane) see where the said Thred crosses your String (or edge of the Plane) and there the true requir'd The Demonstration of this Dial is in the follow-Point will be.

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OPERATION XIV.

How to describe by the Globe a Declining Dial for the Elevation of London.

The fecond way.

Raw your String over at 40 Degrees in the Horizon from The construthe East Northwardly, and from the West Southwardly, as &ion. before, and the respective distances between the Zenith and the Intersection of your String with the Hour-Circles will give you in any great Circle of the Globe the Degrees of their respective distances as well for the Morning as Afternoon, and the proportionable Degrees in any Circle will give you the Points for the Drawing of your Hour-lines, as I showd you in the Construction of the former Vertical North and South Dials; and

as for the Stile and Sub stilar, you must perate as directed in the foregoing Operation, that is to say, the number of Degrees between Z and S gives you the Sub-stilar, and those from P to S the height of your Stile.

The Demonstration of these 2 declining Dials.

As for the Demonstration or Reason why Dials thus made show the Hour, it is this; First you see that the String, by being on one side removed 40 Degrees from the East point Northward, and on the other side 40 Degrees from the West Point Southward, represents on the Globe the requir'd Plane, and therefore wherefoever the Hour Circles cut it, there the Shade of the Axis will fall, as we show'd you before in the former Dials; Now two Points made by the intersections of each Hour Circle with the Plane being given you (to wit, the Center where they all meet, and their respective marks on the String, or supposed Edges of your Plane) it must needs follow, that if you draw Lines throu' those Points, they will be true Hour Lines; for (as we have often faid) the Hour-Lines of all Digls are only the intersections of the Plane with the hour Circles. In the next place, since P S by construction is the nearest distance from the Pole to your String or Plane, it appears that the Hour-cirele which cuts the said Plane at S, falls on it at right Angles, and consequently that as PS (the height of the Pole or Axis above the String or Plane) gives the true height of the Stile of this Dial, to the intersection of the Plane with the said Hour-Circle must be the true Substilar; for the Substilar (as we already mention'd) is only the intersection of the Plane with the Hour-Circle, which falls at right Angles on it; Ergo The distance between Z and S gives in your blind Circle the distance from your 12 a Clock line to the Substilar, and PS the height of the Stile.

A Memoran-

And by the way, here it appears not only why the 12 a Clock Lines of Declining Dials continue perpendicular, but also why their Centers keep the same distance from the Horizontal Edges of their Planes, as do the Centers of the primary Vertical or direct North and South Dials; I say, here all this appears; for the 12 a Clock Line (which is ever the intersection of your Meridian with these Planes) being a Perpendicular in the primary Vertical Plane, becomes the Axis of the Horizon, and all Vertical Dia's by their Declension move only about it, so that both the Center and the said 12 a Clock Line remain the same in all; therefore the Tangent of the Elevation, being (as I

tor-

*formerly show'd you,) the length of the foot of the Stile, or * pag. 84. distance between the Center of a Primary Vertical Dial and its

Horizontal Edge is that of a Declining one also.

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But to proceed with the Demonstration; you must rememmonstration: ber that this Dial is an Horizontal one (as we show'd you *be- + pag. 83. , fore) to those that dwell in the Pole of the Circle describ'd by the String, i.e. to those in our Horizon 40 Degrees Eastward from the Meridian, or (which is all one) to those that dwell where the Thred cuts the Horizon; but all the Hour-Lines are truly drawn according to the former Rules of an * Horizontal * pag. 73. Dial, to wit from the Center to the Points where the respective Hour Circles cut the String or Limb of the Plane, therefore it mult truly shew the hour.

OPERATION. XV.

How to describe Geometrically a Declining Dial for the Elevation of London.

The first way.

THIS Dial being (as I said) an Horizontal one to those in The construout Horizon 40. Degrees Eastward from the Meridian, Etion. Find(as we show'd you in the *Geographical or 20 Section) what * pag. 23. Elevation or Latitude they have, and describe Geometrically an Horizontal Dial on paper for the said Elevation. In the next place consider the difference between both Longitudes, to wit how many Hours the Sun comes sooner to their Meridian than yours, so that if he comes, suppose, 3 hours,'twill follow, that the 3 a clock hour line is to be the true 12 a clock line of this Plane, because 'tis really so late with those People, when 'tis but Noon with you, and consequently that their 4 will be your 1 a clock, and their 2 your 11. and in the like manner you are to mark the rest, having nothing more to do but to draw on your fair Plane a * Line Parallel to the Horizon, and to place on it at right An- * pag 8. gles the true 3 a Clock Line, (that is to fay the 12 a clock line according to your now alteration or present figuring the Hour-Lines,) for you will have all the requisite Marks or Points, not only to draw the other Hour Lines, but also plainly to see, where the Substilar will fall, and how high the Cock it felt is to be; for they are all to correspond with those in the said Ho-

rizontal

rizontal or Paper draught. Now in case the difference of Longitude between these 2 Places happens to be a Fraction, as (suppose) one hour and 10 minutes, then (if the Declination of your Plane be still Eastward as in the former example) to minutes past I must be markt in the Horizontal Draught with the Figure 12, as the Meridian Line, and 2 and 10 min. with Figure 1. and fo on all along; whereas if the Declination were Westward, then 11 and 10 minutes will be the said Meridian Line, 10 and 10 minutes your 1 a Clock Line, &c; for thus you must operate in all other Cases, that is to say, you must still allow by the new figures the difference of Longitude, that chances to be between you and them, to whom the Declining Plane is Horizontal. But because this manner of Dialling may seem to some troublesom and confus'd (especially when the said Difference of Longitude happens to be a Fraction, and not even Hours) I shall here adjoin a second Geometrical Way.

OPERATION. XVI.

How to describe Geometrically a Dial declining 40 Degrees Eastward, for the Elevation of London.

The fecond way.

dion.

The Constru- HAving made an Horizontal Dial for this Elevation in the stion. I lower part of your Paper Plane, (as 'tis exprest by the prick lines in Scheme 18) and drawn from the Center A the feveral Hour-Lines upward as far as you think fit, and Figur'd them to show what Hour-Lines they are, chuse in A C (the 12 a clock line) any Point, suppose P, and draw throu' it the blind Line GD making with the faid AC an Angle of 50 Degrees or Complement of your Declenfion; then erect the Perpendicular PB on the faid blind line at P, and taking with your Compasses (AP being your Radius) the Tangent of 51 Degrees and i, or true Elevation of the Pole, put one foot on P, and where the other marks on the said Perpendicular (suppose at F) there will be the Center of your Declining Dial; fo that having bordred your Plane with fitting Parallels, to contain the standing Figures of each hour, you have nothing more to do,

but to draw fair Lines from the said Center F, to your Border, throu' the Intersections of the Line GD with the several Hourlines of the Horizontal Dial; that is to fay, you have nothing more to do, but to draw fair Lines throu the Points KLMNO PQR which give the hours of 7,8,9,10,11,12,1 and 2; and by the A ready way way you may have as many other Morning or Evening hours as to find the you please if you draw the said GD long enough for the other Stile and Subhour-lines of the Horizontal to meet with it. Nor is there stile of a demore difficulty here about the Stile and Substilar than in any of the former Dials; for (AP being Radius) 'tis but taking the Sine of 40 Degrees (or Declination of the Plane) with your Compasses from the Sector, and putting one foot on your 12 a clock Line at P, the other foot will in the line GD (to wit, at M) give you the Point for to draw the Substilar FM, and the Sine Complement of the Declenfion, or Sine of 50 Degrees, will be X M the Stiles height. Nay, if (for want of a Sector or the like) you cannot conveniently find the Sine of the faid Declension, do but observe where a Perpendicular from A falls on GD suppose at M, and P M will be the distance in the said G D between the 12 a Clock line of this Dial and its Substilar, and AM (equal to X M) the height of the Stile above it. Thus then we see that the Fabrique of a Declining Dial(which is wont to terrify young Students) is in a manner as quick and easy as that of the Horizontal, fince two ordinary Lines more, viz. G D and BP give us all the Points necessary for its Description.

The Demonstration and Reason of this Dial is evident; for, Demonstratithe Horizontal being by construction true, any Erect Plane fa- on. cing the South, that crosses its Meridian (or 12 a clock line AC) at right Angles, will represent a Primary Vertical or Direct South Plane, and then the Center of the Dial described on it will be distant from P the intersection of the two Planes on the said AC) the Tangent of the Elevation, as I show'd you * before. * pag. 92. Now since G Dis (by Hypothesis) the Edge of a Vertical Declining Plane, and since (as we show'd you in the before cited place) that the 12 a Clock line, as well-in a Declining as in a Primary Vertical Dial, is Perpendicular to the Horizon, containing in it the Centers of the said Dials, it follows that FP (being the Tangent of the Elevation, and Perpendicular also to the faid DG where it cuts the 12 a Clock line of the Horizontal) must be the 12 a Clock line, and F the Center of our present Dial,

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Dial, whose Declension is 40 Degrees Eattward, fince F P declines fo many Degrees from CP toward the morning Hours, for the said CP and FP represent the 12 a Clock lines of a Direct. and of our thus Declining Vertical Plane, if you confider them flatted down, and lying in the Horizon. This being fo, 'tis evident that the Lines drawn from F to K L M N. &c. are the true Hour lines of our Dial, as falling from its Center to the several Points made on its Horizontal edge, by the Hour Circles or (which is all The Demon- one) by their Intersections with the Horizontal Dial. As for stration of the the Stile and Substilar, let us but consider the Triangle AMP, and

Stile and Sub-Stilar.

we shall find that P is by construction the Angle of 50 Degrees. and A that of 40, as substended by the Sine of the Decler sion. so that A being a right Angle, AM must be a perpendicular; therefore the Hour Circle, whose intersection the said A M happens to be, falls at right Angles on our present Plane, and consequently gives the Substilar; Now since the Axis of the World passes through F and A, the Centers of the two Dials, when they are joyned (as we now suppose them) at GD the common Section of their Planes; I say, since the Axis passes throu' their Centers, its Elevation or Height above our Plane must be AM, as being the only Perpendicular that can fall from it upon the faid Plane, and consequently its Meafure; but A M you fee is the Sine Complement of 40, fince PM is the Sine of 40, Therefore in all Declining Dials, The Sine of the Declenfion (from their 12 a Clock Line) gives in their Horizontal Edge their Substilar, and the Sine Complement their Stile. Q. E.D.

OPERATION XVII.

To take the Declension of a Plane.

Ompose your Globe and find exactly the Azimuth, i.e. what Degree of the Horizon is cut by the String's shade, when it passes throu' the Zenith and Nadir, which wee'l suppose to be the goth from the South towards the West; then having slipt out (to an equal length) the two Rulers from under your Pedestal, Hold your Globe level, and apply the faid Rulers, as foon as you can, to your Plane, (as you did when you drew an * Horizontal Line) and find again the Azimuth, which now being (for example,

pag. 82.

ample) 90 Degrees shows your Plane declines 40 towards the East, because, the Azimuth being now increast so many Degrees, the Meridian (which by the help of the faid Rulers was perpendicular to your Wall or Plane) is turned thereby from true South (as formerly it stood) towards the East the abovementioned number of 90 Degrees; but had the shade fallen on the 10th. Degree, your Plane would (for the fame Reason) have declin'd 40 Degrees towards the West. In short therefore, the difference of these two Azimuths is the thing that resolves the Question; for when they are equal there is no Declension at all.

of Reclining Dials.

THE Horizontal Plane lay open (we faw) to the whole Hemisphere, whilst each Vertical one enjoy'd but half of it; for, by being Vertical, a moiety of the said Hemisphere is before, and the other behind it. Now the Reclining Plane (which is exprest by sch. 29.) instead of being perpendicular to the Horizon bends towards it, yet so, that its bending has nothing in it of overwhelming or tendency towards those, that behold it (as it happens to Inclining Planes exprest by * Scheme 30) but ftill receeds, according to the Degrees of its Reclination, farther wid. page and farther from them, making thereby an obtuse Angle with the Horizon, and consequently faces more than half the apparent Heavens, as the Inclining one does less, whose Angle is therefore ever Acute.

As for the kinds of Reclining Planes, there are (I may fay) 4, to wit, the Equinoctial, the Polar, the Direct Reclining, and the Declining Reclining Plane; for each of these appropriates to it felf a particular Fabric, or way of making, and therefore we will Treat of them in Order.

OPERATION XVIII.

How to describe a Dial on an Aquinoctial Plane, both by the Globe, and Geometrically also.

THIS Plane is represented by the Globe, when 'tis Compos'd The construand cut (as in Scheme 20) quite throu' at the Aquino- Etion and De. dial, therefore open your Compasses at 60 Degrees there, and monstration, de-

describing the Blind Circle ABCD in Scheme 21, divide it as the Hour-Circles cut the said Aquinoctial (in Sch. 19th.) that is to say, divide it into 24 equal Divisions, and there will rest nothing more to be done, but to draw Lines from the Center O, through as many of those Divisions as you shall think necellary, and then to Figure them fuccessively from Morning to Night. As for the Stile (feeing the Axis of the World is at right Angles with any Diameter of the Equator, and runs throu' the Center of it) it must needs follow that the Perpendicular Pin OF plac't in the Center of your Dial, will perform that Office; for when it directly points to the Pole it represents the said Axis, as the divided blind Circle does the Aquinoctial, and its Divisions; therefore since the Shade of the Axis ever falls (according to the time of the Day) on This or That interfection of the Hour-Circles with the Equator, the Shade of the Pin must fall also on the corresponding Hour-line of the Dial; as being (in the effect) the same thing, in case the 12 a Clock Line be plac't on a Meridian line, and mounted at A (its South fide) above the Horizon, the Complement of the Elevation of the Pole, i.e. 38 Degrees and a half for by this means your Plane, from an Horizontal one, will be perfectly that of the Equator.

How to make an Horizontal Plane an Aquinoctial. one.

Bration.

Nor is it hard to mount thus the faid South fide of your Dial, fince 'tis but opening your Compasses, in any great Circle of your Globe at twice as many Degrees as is the Complement of the Elevation, to wit 77 Deg. and they will give you the true length of a Perpendicular to underprop withal the aforesaid A, The Demon- or Southern point of the 12 a clock line of your Dial. And the reason of it is because AC the Diameter of your Dial being (by Hypothesis) equal to the Diameter of the Globe, becomes now (C being Center of the new Arch, made by the mounting or raising the side of your Plane above the Horizon) a Radius double to O A the former Radius. Therefore since the Chord of a double Arch is ever the Sine of the single Arch in a Circle, whose Radius is double the other, it follows that the Chord of 77 Degrees is (in respect to the double Radius A C) the Sine of 38%. 30 m. and consequently will perform (if exected Perpendicularly) the design'd Operation.

The Geome. trical Con-Strnetton.

Now for the Geometrical Construction of this Dial, (fince it confifts only in dividing a Circle into 24 equal parts, with a

perpendicular Cock or Stile,) there is no need of more words about it; fo that we'l end here with a Memorandam, viz. that as the Reclining face of this Plane, thews the Hour from Spring A Memoranto Autumn, so the Inclining Face, or other side of it does the same, for the remaining half year, to wit, from Autumn to the Spring, boo O noowred esantilla ercalins mentioned in the Doler in

OPERATION XIX.

How to describe a Polar Dial, both by the Globe, and Geometrically also.

THE true Plane of this Dial is speculatively the Plane of the Aquinoctial Colure or 6 a Clock Hour-Circle, but in practice that of any Circle parallel to it, fo that the Construction and Demonstration of a Dial on it, is (mutatis mutandis) the same with that on a Meridian Plane, of which

we have already so fusely * treated.

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Make then by your Globe (for example fake) an East Di- The Construal on a Meridian Plane, according to any of the former ways, and if you alter but the Figures, that is to fay, if having figur'd the Substilar instead of 6 with 12, you mark the Morning 7 a Clock Hour line of the said East Dial with 1, that of 5 with 11, and fo on in Order, it will be a true Polar Dial, showing you exactly the Hour, when it directly faces the South, and Reclines to, that the Apex or uppermost part of the Substiler or 12 a Clock line points just to the North Pole; for then the back-part of the Plane makes an Angle with the Horizon equal to that of our Elevation.

This Operation may be also perform'd of it self without the former confideration, fince tis but putting one foot of your Compasses on the Intersection of your Meridian or 12 a Clock hour Circle with the Aquator of your Globe (to wit, on K in Scheme 22) and so describing with Chalk the Arch CE, I mean an Arch which reaching from the faid Meridian, cuts the Morning 7 a Clock, or if (you please) the Evening 5 a Clock Hour Circle somewhere or other; for then if you draw a blind Gircle (as in Sch. 23.) of the same bigness, and take the seve-

Sacing the

ral distances between the Pricks or intersections of the Hour-Circles with the said Arch, to wit, the distances between C and O, C and S, &c. and place them on the blind circle, on both sides of P C. K with the Substilar or 12 a clock line, as well below the line Æ æ, as about it) the lines drawn from the said Pricks will be true Hour lines, and the distance between C and P or between K and X will (for the reasons mentioned in the Descripti-

on of the Meridian Dials) be the height of the Stile.

Now to describe this Dial Geometrically, 'tis yet more easily performed, for if you draw (as in Scheme 24.) the Line A B parallel to the Horizon, and then take a Point in the middle of it (suppose K) do but prick on both sides of it the Tangent of 15, 30, 45, 60, and 75, and the several Perpendiculars drawn throu these Pricks will be true Hour-lines, which you may sigure as you see in the before mention'd 24th Scheme; and as for the Stile the Tangent of 45, (or distance between the 12 a Clock line, and that of 9 or 3) gives you its beight, which is to be a Pin or Gallowes Stile as before, and the 12 a clock line the Substilar.

OPERATION XX.

How to describe a Direct reclining North or South

The Construation and Demonstration of a declining direct Dial facing the South.

Suppose then that the Plane lay directly South, and that its Reclination were 20 Degrees, you have nothing to do, but either Geometrically to make on it a direct Vertical South Dial for the Elevation of 71 Degrees and [(I mean for a Plane 20 Degrees neerer the Pole than your own Zenith) or to fix your String on 71 gr. and 30 min. in your Meridian (that is to say at A in scheme 25th. and then to draw your said string over the East or West Points of your Globe, for 'twill represent this Plane, since it Reclines or falls back from the Zenith 20 degrees; therefore the Distances between the Hour Circles that intersect with your String, must (for the former reasons) give you in any blind Circle (which shall be equal to a great one on your Globe) marks (viz. b, c, d, e, f, g,) for the corresponding Hour-lines; and the Meridian being the Substilar (since 'tis

the Hour Circle that falls on the Plane at right Angles) the Height of your Stile must (as in all Direct Vertical Dials) be the distance from the Pole to A, the supposed Point, or Place A Direct where your String is fixed. Now had your Plane Reclin'd 20 North recli-Degrees theother way, that is to fay, had it Reclin'd fo many Degrees facing the North, you must have fixed your String at N, viz. 20 Degrees fhort of the Zenith, and consequently your faid String would have interseded with the Hour Circles at o. p,q,r,f; therefore a Direct Vertical North Dial for the Latitude of 31 g. 30 m. will be the required Dial.

OPERATION. XXI.

How to make a Declining Reclining Dial by the Globe.

CUppose your Plane declin'd 40 Degrees Eastward (as did the I late Declining * Vertical) and then Reclin'd 20 Degrees * pag. 89. with a Southern Aspect, and by the way you must remember, that I mean in general by a Planes Reclining with a Southern Aspect, its looking towards that Quarter, tho it be turned more or less from Direct South towards the East or West; in like manner a Declining Reclining Plane with a Northern Affect turns from direct North towards one of the aforesaid Points. posing then a Plane thus Reclining, Do but describe or place it on your Globe, and your Operation will be as easy as any of the former.

First mount your Bead 71 Degrees and half above the Hori- How to dezon, that is to say fix it to 20 Degrees from the Zenith of the Scribe the Globe; then seeing your Plane has a Southern Aspect, (and so lies Reclining Dibeyond your said Zenith Northward) move your String till it al on the cuts in the Horizon 40 Degrees Westward from the Northern Globe. Meridian, or back part of the 12 a Clock Hour Circle. In the next place take a Thred and tying it about your Globe fo. that it lies not only on your Bead, but crosses also the Horizon at 40 Degrees from the East point Northward, and 40 Degrees from the West Point Southward, the said Thred will represent your Plane Reclining and Declining, as aforesaid. Or, in short fix, a small Needle in the Point where the Bead lies (which we suppose at A in Sch. 26.) and fastning to it a Thred or part of the:

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The Constru-

This being done, describe a blind Circle or Semi-Circle equal to a great one on your Globe, for Example fake, the blind Semi-Circle A. T. C, and drawing from (O) the Center the blind Line O A perpendicular to the Horizontal line H b, take the distance with your Compasses between A the station of your Needle or Bead, and the point in the 12 a clock hour Circle crost by the Thred or Edge of your Plane, and this distance from A in your blind Circle, gives you there towards your left hand the Point k, to which if you draw a fair Line from the Center it will be the 12 a clock Line of your Dial. and the distance from the said station of your Bead or Needle to the intersection of the Three with the next Hour-Circle will give you I, the mark of the II a clock Line; and in this manner you must run over all other intersections of your Thred and Hour-Circles to the very Horizon on both fides of the Globe (I mean on the Morning and Evening fide of it, represented by Scheme 26 and 27) and placing their distances on your blind Circle, on both fides of the aforesaid OI, do but draw lines to them from the Center, and your Dial is describ'd.

A Memoranaum. And here you must observe that I have (in Scheme 26. or Eastern Face of the Globe) plac't A(the Station of the Bead or Needle) above the Meridian, since its true place cannot be express; for it ought to have bin on the other side of it, I mean on the Western side, which Scheme 27 is supposed to represent.

Of the Stile and Substilar

Now for the Stile and Substilar there is no difference from the Rules of the Declining Vertical, fince 'tis but finding the nearest point on your Thred to the Pole by your Compass; for the distance between the said Point on your Thred and it's intersection with the 12 aclock Hour-Circle is the distance in the blind Circle between, k and M for the Substilar and the distance between the said neerest Point and the Pole, gives M X the height of the Stile above the Plane. Nay, if you measure the Distance between each Point and A in any great Circle, 'twill give you the Degrees or Distances between A and your Stile, Substilar, and each Hour-line, and consequently performs

pag. 82.

the second way (as we have all along mention'd) of describing Dials by the Globe, and a han any work of him

As for the Demonstration of this Dial, what we have for- Another Demerly faid about the rest proves it also; for supposing that the Thred represents truly your Plane, and that the Hour lines of a Dial, are (as I have show'd you all along) the several intenfections of the Hour-Circles with the Plane, this Dial must be true, since all the Lines on it are the said intersections, as drawn from its Center to the Points made by the Hour-Circles on its Edges: Nor can there be any error in the Substilar or Stile, the first being the intersection of the Plane with it's true Meridian of the Plane, I mean with that Hour Circle which falls on it at right Angles, and the other being the real Height (as you see) of the Pole above the Plane, ergo, the whole must be true.

monstration:

OPERATION XXII.

How to describe by the Globe a Dial Declining and Reclining as the former, with a Northward Aspect.

Here is no need here of a Scheme, the Construction of this The constru-1 Dial being in a manner the same as the former, only now Stion. you must draw your String and Bead (fitted to the Reclination) the contrary way, that is to fay, over the South or forepart of the Globe throu' the 40th Degree in the Horizon East-ward from the Meridian or 12 a clock bour circle, then fixing a Needle (as * I show'd you) on your Globe, or esse tying a thred tound it so, that it crosses still your Bead, and the aforesaid * pag. z. two Points in the Horizon, you have there the Plane reprefented, and may consequently (by the help of the former Intructions) describe this Dial, whose Stile is to point upward, because of its Northern Aspect.

de dente OPERATION. XXIII.

How to describe all Inclining Dials, whether Direct or Declining.

N Inclining Dial (of what fort soever it be) is the back or A hinder part of a Reclining one of the contrary Aspect so that its hour-lines must be mark with the opposite Figures, and

the Stile must point the other way; therefore if you desire a Dial Declining East-ward 40 Degrees, and Inclining 20 with a Southern Affect, describe only the last Dial, (which has, you see, the same Declination and Reclination with a Northern Affect) and then if you mark the Morning hour lines with the Evening Figures, and place the Paper draught the contrary way, that is to fay, let the Apex of the stile point downwards, you will perform the Operation.

As for the Geometrical Description of Reclining or Inclining Dials since 'tis very intricate, I shall not now trouble you with ir, especially having already show'd you so facil a way by the

Globe.

OPERATION. XXIV.

How to find the Degrees of the Reclination or Inclination of any Plane by the Globe.

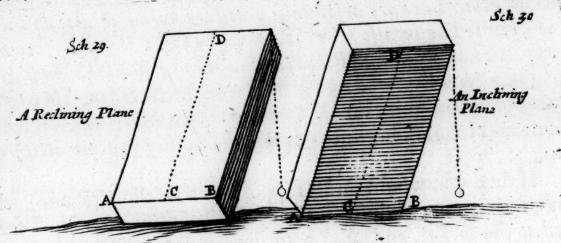
First way. * pag. 4.

Here are two ways to perform this Operation; for first (as I show'd you in taking the * Level of a Plane,) the String rests just on the Horizon of the Globe, when it stands on an Horizontal Plane, or one 90 Degrees from being Erect and Vertical.

Draw therefore on the Reclining Face or fide of the Plane (represented by Scheme 29.) a Line parallel to the Horizon (suppose A B) and let fall the Perpendicular C D, then place the Notches of the Pedestal of the Globe (mark't with S N) on the said Perpendicular, and consider what Degree in the Meridian (counting from the Zenith) the String just lyes or rests upon, and that will be as well the Inclination, if the Plane inclines, as the Reclination if it reclines; for the Complement of this (I mean the distance between the Point, or Resting place of the String and the Horizon) showing always how much the Plane want's of being * Level or Horizontal, the Degrees from the Zenith, must needs show how much it wants of being Erect or Vertical.

* pag. 4.

As for the second way, Draw a Perpendicular on the Recli-The second ning side of your Plane, as I now show'd you, and placing on it way. (after the same manner) the Notches of the Pedestal, expect 'till the Shade of the Pin in the Zenith salls upon the Meridian of your Globe; for this show's the Sun to be at that moment in the Plane of the said Meridian; then observing on what Degree of it the Shade of Extuberancy salls, place but your Globe Level or Horizontal with your Meridian in the Plane of the Sun as before, and as the difference of these Degrees shows how much your Plane wants of being Horizontal, so that the Complement show's what it wants of being Erect, and consequently the value of its Reclination if it reclines, or Inclination if it inclines.



You may also if you please draw your Perpendicular on the Inclining side of your Plane (as in Scheme 30th) but then the requir'd Inclination, if it inclines, or Reclination is it reclines, will be the difference in Degrees between the aforesaid shades of Extuberancy, after you cast away 90; for by how much the Inclination happens to be, by so much the shade of Extuberancy exceed's 90, since 90 is the difference between an Horizontal, and an Erest Plane.

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OPERATION XXV.

How to find how long the Sun can possibly shine on a Plane, as also (from time to time) when we may expect him after his Rising to come on, or before his Setting to go off the said Plane.

Defer'd this Operation till we had treated of all Planes, because the applying of it would then be better understood. Tis (tho' obvious and easy, of great Use) as not only showing us what Hour lines are absolutely necessary on all Dials, and what not, but telling us also at what a clock (all the year long) we may expect the Sun on our Plane, and at what a clock he must go off it; for (notwithstanding He be above the Horizon, He will not always so long shine on a Plane not Horizontal, as by the Earliest and Latest hour lines (that may be justly exprest on it) one might expect.

The first part of the Operation.

If then you would find (suppose on a Declining Plane) what hour lines may be justly and necessarily drawn on it, I mean what the earliest and latest hour lines ought to be, you are only to draw you String from the Zenith (according to the Declension) on both sides of the Meridian (or 12 a clock hour circle) to the very Horizon; that is to say, you must operate in the same manner as you do, when you describe the Plane in the Fabrick of this kind of Dial; for the Hour circles cut by your said String in the Horizon show you exactly how early he can come on, and how late he can flay on it; so that to express further Lines were needless. This then makes you stop at 4 in the Afternoon in your late * Example, where the Plane declines 40 Degrees Eastward, whereas had it declin'd but 20 your earliest hour (as you may fee if you try) would have bin five in the Morning, and the latest five at Night. In short, describe your Plane (let it be what it will) on your Globe with your String, and your Hour circles, (as we faid) that intersect with it in the Horizon answer the Question, fince it clearly appear's (your String ever representing the Edges of the Plane) that if the Sun lyes Easterly in the Morning, and Westerly in the Evening

* pag.89.

of the Hour-circles, that meet your String in the Horizon, He must be behind your Plane; therefore since he is not then able (tho' up) to shine upon it, 'twere needless (as we said) to express more Hour lines.

'Tis the Describing also of the Plane with your String that The second brings us to the knowledge of the second part of this Operation, I part of the mean the knowing at all times when the Sun comes on, and goes Operation, off any Plane; for having describ'd one (Declining, v.g. 20 Degrees Bistward) do but observe what Diurnal Parallels and Hour-circles intersect on the Edges of your Plane, and you have your Intent; for you will by this means see, that, (tho the Sun rises (for example sake) on the 11 of June before 4) the first hour circle, which intersects with this Parallel on the Edges of the Plane, is that of a Quarter before six, whereas about the beginning of May, he is there at half an hour past sive, and on the 10 of April at or near 5. Now if you consider in the same manner the West-side of the Globe, you will see from time to sime at what hour he goes off it; and thus you may do, let the Plane be what it will.

Here therefore it evidently appears, if you should erect at a- Why every Eny time (suppose about the 10th of April) a Perpendiculur stile rect Stile or on an Horizontal Plane, and draw every Hour a Line along the perpendicular Shade of the said stile, why such a Dial will be false, as only tel- mays the true ling you the true Hour twice in the year, to wit on the 1 oth of Hour. April, and about the 1 oth of August, viz. on the days on which the Sun run's in the same Diurnal Parallel; I say, all this now evidently appears, fince every Line thus drawn on an Horizontal Plane (except the Meridian, or 12 a clock line) is no Hour line but an Azimuihal Section; I mean the Section of the said Plane, with a Circle that then passes over your head throu' the body of the Sun; so that if one of these Lines should Bear (suppose) almost S E, and be figur'd with 10 in the morning, Draw but your String from the Zenith, over that Bearing, or Point of the Compass in the Horizon of your Globe, and it will truly represent the said shade or Line on your Plane; for it show's it to be 10 of the Clock on the Parallel belonging to the faid 10th of April: But fince your String cuts also on your Globe (v.g.) the Tropic of up at a little before 9, and the Tropic of 5 at almost half an hour past 10, you may conclude that this will be the true time of the Day on the 11 of December, and 11 of June,

tho' the shade of the Perpendicular stile still show's 10 a clock at the aforesaid Bearing, let the Season of the year be what it will; therefore a Dial thus made must be false.

of several ingenious and humer some Dials.

HAving thus run throu' all Planes, I shall at present show you how to make use of the former Principles, as to the ready Describing of several ingenious and humersome Dials, for all are now in a manner but Corollaries from what we have already faid, and confequently easy both in Speculation and Practice.

OPERATION XXVI.

How to make a Dial on any Plane whose stile shall be an Arrow fixt casually on it.

Etion: * pag.89.

The Constru- Xamine what the Plane is, and having found it to be, suppose, a Vertical one Declining 40 Degrees East-ward, describe by your*former Rules: such a Dial on Paper with the Paper stile F x, M. (as in Scheme 31.) exactly set, and mounted; then draw on the Plane an Horizontal Line Hb, and place on it your said Paper draught so, that the 12 a clock Line F P may fall at right Angles on the said Horizontal line. Lastly, move your Draught along it, till some part of F x or Indicating side of the file, (suppose the Point A) just touches the Top or most prominent Part of the Arrow, and fixing there the faid Draught, if you draw fair Lines on your Plane under those on the Paper, the faid Arrow will always show you the Hour with its Top.

The Demon-Stration.

* pag. 94.

The Reason is plain: for you see by the said Top's just touching the Edge, or Indicating side of the Paper-Stile, it has the effect of the Top of A B, I mean the Top of a Perpendicular falling from the faid side on the Sub-stile, so that X the Top of XM (both in the present scheme and also in Scheme * 18. or Example of a Declining Plane) has this Effect also. the Top of AB or X M or of any other Perpendicular, that falls

from

from the Indicating side X F on the Substile F M will perform the Office of the stile (as we show'd you at large in Demonstration of the * first Horizontal Dial or first Example,) it must * pag.75. necessarily sollow, that A the Arrow's Top do's the like.

OPERATION XXVII.

How to make a Dial to Show the Hour without a stile on any Plane.

DEscribe (as in Scheme 32.) a Dial on P the given Plane, and erect for the present a true stile (as F A B) of Paper or the like, then fixing a Glass or any other transparent matter (suppose G) at what distance you please, before the said given Plane and Parallel to it, mark where A the Top of the Stile just touches the said Glass; and if there you paint a little Asterisk or spot, it will (as often as the Sun shines) describe such another Figure (at suppose D) by its shade on the said Plane P, and move also from Hour Line to Hour Line, according to the true time of the day.

The reason of this is also Evident; for, if A the top of the real Demonstra-Stile show's the Hour by casting a Shade (as we show'd you all tion. along) on the Hour Lines, then the Asterisk being there painted where the said Top touches the Glass, must do the like; for it is, you see, the Stile's Apex or Top, and consequently casts a true shade to know the Hour by.

This Dial serves not only for all double Windows, or for Cavi The Advanties that have over them any Glass or Transparent matter, but tage or use shows us how to make one for any Plane, that is illuminated by of this Dial. A Ray coming throw a Hole, since if you describe the Planes proper Dial on Paper, and move it duly (as before) on the said Plane, 'till the Stile, or (if that be too short) 'till a Thred drawn along its Indicating side, touches the Hole, it will give you marks for the drawing the fair and standing Hour-lines of your Plane, which the said Ray will dayly run over in order, and consequently show you from time to time the Hour; for the Ray passing (as you see) throu' the Hole(v.g.) at A, and salling on the true Hour Line at D, performs what A, the Apex of the true Stile (FAB) would do.

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OPERATION XXVIII.

How to describe a Dial, having a Picture of a Manin it, that shall Point to the Hour from time to time with his Finger.

THIS Dial is on several Planes of Mr. Lines his sorementioned Pile in Whitehal Garden; and as no Dial can be more useful, so perchance none ever struck the Fancy, both of the Ignorant and Learned, with a more sudden Admiration than this, as I have often found by Experience, both in England, and elsewhere. Nor truly can it but surprize one at first to think, that a Picture (without a Machine or Movement) should have his Finger ever on the Hour, and as duly attend the Sun's motion, as if he were alive; I say, this cannot but surprize one, and yet this very Dial is as easy to be made, as any of the former.

The Confiru-

Suppose then (as in Scheme 33) that the Plane given you were that of the Vertical Cavity, a b c d, lying directly South; describe therefore on the Glass (A B C D) the contrary Dial, i. e. a Direct North Dial, with a Paper Style truly mounted; and placing the said Glass over the Plane, and Paralel to it, see where the Stile just touches the said Plane, and at that point (suppose E) let the top of the Pictures Finger be painted; then throwing away your Paper Stile, and now (by the Help of a handsome Frame or the like) fixing there your Glass, all its painted Hour Lines (by hindring the Sun's Passage or Light) will project so many Dark Lines on you Plane, whilst the then true one falls directly on the Mans Finger, and confequently shows you what a Clock it is.

Demonstra-

For if there were a Hole that passed at E (the Top of the Mans Fingers) throu' the Center of the World to our Antipodes, it necessary follows (by the Reasons in our former Operation) that at 10 of the Clock, (suppose) at night, the Sun (being then Northward) must catt its Rays throu' the said Hole or top of the Finger, on the 10 a Clock Line of this North Dial on the Glass; but since at 10 a Clock in the morning, the Sun is in the same Plane as he was at 10 at night (only his Station is contra-

ry) therefore he must now cast the Shade of the Hour Line the contrary way, i. e. on the Mans Finger; for, in the day time the Hour-line is between the Sun and the Finger, whereas in the night time the Finger or Hole is between him and the Hour-Line.

This Dial needs not always be made on a Glass, for 'cis suffi - Another Dial cient if you raise a thin Frame (a a a a in Scheme 34.) on the of the same Pillars bbbb, above P your Plane, as high as the Glasse's true Station or Place, for then you may cross the said Frame with small Strings or Wyars, which will by their interposition cast the same shade as the Hour-lines of the Glass would have done; so that if the Figures belonging to the said Lines be put on the Frame, at the end of each corresponding Wyar, and then pierc'd, the Sun Beams passing throu' their Cavities, will distinguish each very perfectly on the Plane.

Tho I have not time to show you all the particulars of this Learned Man's rare Invention in Dialling; (for most of the Dials on the aforesaid Pile may be naturally and expeditely defcrib'd by the help of this Globe) yet I will give you two more, viz. the two following ones, because, besides their prettiness, we may have use of them, as you shall see by and by.

OPERATION XXIX.

To make a Dialby which a Blind man may constantly know the Hour. ke a Dial to the Dehie Steer who

YOU must first get made in Brass the Armillary Hemis- The constru-phere ABCD E (as in Scheme 35) 8 Inches, suppose in ction. Diameter, representing your Globe cut throu' the Horizon; but the said Hemisphere is not to have any thing solid remaining, besides the Horizon ABCE with the Pieces of the Hour Circles (1 2 3 4, &c) that reach to it from the Nadir, or rather from the Tropic of Capricorn AFC on the Northernside, for the Southerly Circles are superfluous. Then having plac'd the faid Hemisphere directly North and South, as your Globe stands when Compos'd, fix G a Glass Bowl of clear water 4 Inches in Diameter (i.e. half the former) in the midst or center of it; for the Sun's Beames passing throu' the Water will contract in a Point,

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Point, and ever burn at (suppose H) the true Hour-Circle; so that if a Blind-man puts but his Hand on the said Brazen Hour Circles, he will soon find by the Heat where the Sun marks, and consequently tell you the Hour; for he may easily feel how far it is from the middlemost Hour Circle, I mean the 12 a Clock Circle or Meridian.

The Demonstration.

As for the Reason of this Operation, 'tis presently conceiv'd; for when the Sun is over against (suppose) the 5 a Clock Hour Circle on the South-side of the Dial, he must needs be over against the same Hour on the Northside, both hours making but one Circle; Now since the Center of the Bowl (by being in the Center of the Hemisphere) is in the Plane of all the Hour Circles, and fince (according to the nature of Refraction) all Paralle Rays of the Sun, passing throu' a Sphere of Water, are (where they meet with the Direct Ray, that passes throu the said Center) contracted into a point, viz. on the opposite side, at the distance of half its Diameter, or two Inches according to our present Example; I say, seeing this, it must needs follow, that at 5 of the Clock, the Sun will burn on the corresponding Hour-Circle, and if so, then a Blind-man (by feeling the Heat, and finding its distance from 12) must needs be able to tell you the true time of the Day.

OPERATION XXX.

To make a Dial to show the Hour when the Sun Shines not.

The Constru-

PRepare a Blew Glaß Bowl, (as in Scheme 36th) and describe on it (with their Respective Figures) all the Hour-Circles of the Globe, or as many as you think fit; then fixing it where you intend, and composing it truly by your Globe, if you place your self so at some Distance, that (a little Hole being made at each Pole, to wit at P p) you may see quite throu' the Bowl, twill sollow that the Hour-Circle (suppose A, which the Sun's Picture appears on) will be the true time of the Day. I call this to know what a Clock it is when the Sun shines not, because now the least faint Appearance of him serves the turn, tho' it be not enough to cast any shadew; nay let the Sun be quite cover'd,

and

and if you can but guess (by the Adjacent Brightness,) whereabout he is, you will be able to guess the Hour without any sensible Error; for the said Brightness appearing on the Bowl will be proportionably distant from the Sun's true place there, as 'tis from the Sun in the Heavens.

'Tis clear that the Suns Picture must fall (if any where) on the Demonstratrue Hour-Circle, because (by Composing the Bowl according to tion. the truePosition of the Heavens) the Hour-Circles of the one concur withthe other, and fall exactly in the same Plane; therefore were your Eye in the Center of the Bowl, its true Hour Circle, (i.e. that which corresponds with the time of the Day,) would be just interpos'd between your Eye and the Sun; but fince the whole Axis is the common Section of the Hour-Circles, let your Eye be but in any part of it, the same Interposition must happen; fothat feeing the Suns Ray (by reason of the Blew Colour) penetrates not the Glaß, his Picture must needs be on the outside of it, where the said Ray would have otherways past; Now the Ray that goes from your Eye throu' the two Holes being the Axis, therefore whilst your Eye remains in this Posture, it will follow that wherefoever you fee the Suns Picture on the Glaß, there his place must be, and consequently his said Pi-Eture must show the Hour.

OPERATION XXXI.

How to make an Horizontal Concave Dial by the Globe, and Geometrically also.

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Compose so your Globe in the Concavity given (suppose The Constru-BAC in Scheme 37.) that A the Center of the said conea-tion. wity shall concurr with the Center of the said Globe; then drawing your String over each necessary hour Circle on the Globe to the sides of the Concavity, mark as many Points, as shall be convenient for the Describing the corresponding hour Circles, and the Pin (AD) erected in the Nadir at Das high as the said Center A, I mean a Pin equal to the Semi diameter of the Concavity, will with its Top always show you the hour.

Tho the former way be impracticable when the Hole is less The Geomethan than trical way.

metrical Operation; for you have nothing (you see) to the but to draw hour Circles within as you would without, were the said Concavity a whole Sphere, and then the Top of its Semi-Diameter (i.e. the poynt which lyes in the Center A) will perform the Stiles part; for since the Sun is every Hour (as we have before showd you) in the same Plane of the true hour Circle, and since A the Top of the Semi-Diameter (being in the Genter of the Concavity,) is part of the Axis (or Common Section of all the Hour-Circles) it sollows, that its Shadow must fall on the true Hour.

The Demonfration.

OPERATION XXXII.

How to describe Geometrically a Cieling Dial.

Steing the Glaß (which reflects the Suns Rayes to show us the Hour) is commonly fixt in the corners and by-places of Windows, the Globe can seldom be so well order'd (by reason of its Bulk) as to help us in the Construction of this Dial, therefore I shall only give you the Geometrical way, which is (as I take it) both short and new; and because these Dials have commonly the windows (or inlets for the Sun) Southerly, for otherwise they will show but very sew hours, we'l suppose ours also in the following Example to stand thus, and afterwards you shall see the difference between such a Dial, and those whose Windows have another Aspect.

The Constru-

First make on any Past-board, Trencher, &c. an Horizontal Dial, as in Scheme 38. and fix in O its Center a Thred of a good Length, to wit O P; then sasten the said Dial so with a Nail to a Long Masons Ruler, that its Fiducial edge (KL) may lye upon the Meridian or 12 a Clock Line, and having cemented and plac't Level a piece of Looking Glass (of the bigness of a Three pence) in the Window, or what convenient place else you please of your Chamber, (which we'l suppose to be G) find by the Plumet A E the Poynt A in the Cieling (WXYZ) being the poynt (in Scheme 39.) directly over the said G, and draw throu' it a Meridian line, viz. the Line A L.

In the next place, fix one end of a piece of Packthred on G.

the

the Center of the Glass, and the other on some point of your Meridiandine in such manner that it make an Angle with it of 51. 30'. i. e. the Angle of the Elevation, which may be easily perform'd by the application of the fide of a Quadrant to the said extended Packthread, and when 'tis right, let the Point thus found in your Meridian line be called B. Lastly, take the distance between the aforesaid Points A and B, and marking it, suppose at C, on the edge of your Ruler from O, the Center, (or fastning of the HoriZontal) place so the said Rulers Fiducial edge (KCL) along the Meridian line on the Cieling, that the point C may lye just on A, and all is done; for then if you draw but the Thred O P streight over each Hour-line of the Horizontal, it shows you where you are to draw all the fair Lines of the required Dial.

Sch. 40. South North

As for the truth of this The Demon-Dial, it appears (in Scheme stration.

40.) by the right Angle Triangles OGH and GHP, where HF is part of HM, N a suppos'd Meridian line on the Floor, under that in the

Cieling, G the Station of the Glass in the Window, H the Point under the said Station, as formerly A was the Point over it; and to facilitate the Demonstration, let us imagine GH equal to GA, i. e. that the Glass lyes in the middle, between the Floor and Cieling; This being so, suppose that G H (instead of representing a Perpendicular Line in the Wall (as here we conceive it) had been a Perpendicular Stick, and that you were to describe an Horizontal Dial on the Floor, whose Stile was to be the said Stick; I say supposing this, you must (you know) to perform the Operation, produce the Meridian Line MH to Suppose N, and fastning a String on G, find in it the Point (v.g.) O for the Center of the Dial, (I mean a Point, to which a String being extended from G, makes with the Meridian (OH) the Angle of the Elevation) and so draw the several Hour-lines from the said O according to their respective Angles and Distances; all which is exprest at large in the third * Scheme or first Horizontal Dial; for there (you see) GH is a * pag.7 3. Perpendicular Stile, showing the Hour with its top, and that O

is the Center of the Dial, having a Line drawn to it from G making the Angle of the Elevation with the Meridian OH. Now fince O in our present case is a point without the Chamber and consequently the Line MH cannot be produc'd to it, you must draw your Thred from G to the faid Meridian Line (HM) within the Chamber, and find in it the Point F, to wit the Point where the faid Thred GF makes with it an Angle equal to that of the Elevation, for thereby you will have the distance of O, your true Center from H, as being the distance of F from H, feeing the fide GH is common, and the Angles in both Triangles equal: This being fo, if you put out of the Chamber an Horizontal Dial whose Center shall lye on O, and its Meridian Line concurr with H F, 'tis but producing all its Hour-Lines on the Floor, and it must necessarily follow that G the Top of the Perpendicular Stile, will show you truly the time of the Day; But by Construction all the hour-lines are thus drawn on the Cieling, and confequently are exactly over the supposed ones on the Floor, Ergo, the Reflext Ray from G must as truly show you the Hour above, as the Direct Ray below; for both Rayes are ever in the fame Plane.

How this Dial is to be made when the windows tye not Southmard.

Nor is there to be any real Difference in the Operation tho's the Chamber-window should look another way; for you are only to remember, that whilst it enjoys the least Point of South, the Center of your Dial is without the Chamber, when it looks sull East or West 'tis in the side or edges of it, and when it verges Northward, 'tis altogether within; so that in a full Southern Aspect, the said Center will be most abroad, and in a sull Northern one the Contrary; all which plainly appears to any one, that will consider an Horizontal Dial truly plac'd (having a Perpendicular for its Stile) if he draws over the Hour-lines, a Line that shall represent the aforesaid side of your Chamber according to its Position and Site.

OP E.

OPERATION XXXIII.

To make a compound Dial, to wit, one containing several ufeful Operations. de aus sot an varb

Nnumerable are the ingenious Dials that may be invented, but fince we have been long enough on this Subject, either for my Reader's Speculation or Curiofity, I will now conclude, and that with a Recapitulation or fumming up of much of what we have already said, by showing the Fabrick of a Compound Dial; that is to fay, one that contains many useful Operations, besides the Hour; for nothing rubs up the Memory more efficatiously, or makes us more Masters of our Rules, than a Practical Example.

The faid Dial shows as follows.

1. The Hour with us at all times.

2. The Hour in what other Countries you please.

The Sun's Place in each Sign.

4. The Day of the Month.

The time of the Sun's Rising and Setting.

The Sun's Amplitude.

. The Sun's Height.

8. The Sun's Azimuth.

9. The Sun's Bearing according to the Points of the Compaß.

10. The Proportion between Perpendiculars and their Shadows, and consequently the height of any Tower or the like.

To make then this Dial, you must first describe an Hori- The constru-Contal (as in Sch.41.) about a Foot in Diameter, and let B the dion of it, as Center of the Plane be the Point, where an Erect, or Upright at home. Stile (according to our Directions in the "first Horizontal,) * pag. 73. shews you with its Top the Hour. Now because the Shade of an Upright Stile, unless it be very short, will presently fall out of the Plane, as well in the Morning as toward Night, there-

therefore it will be convenient to have your Cock or Stile made so, that A B the Perpendicular or fore-part of it (as in Scheme 42.) should stand at B the faid Center of the Plane, to reprefent this upright Stile, and its Angle AOB at O the Center of the Dial, or Point from whence all the Hour-lines are drawn; for thus the fide OA (making with the Meridian line at O, the Angle of the Elevation) represents the Axis of the World, and consequently casts its shadow on the Hour-lines, as the usual Cocks of all Horizontal Dials do.

The Constru-Etion of it as to the Hour ces.

2. Having chosen all the Places, which you defire from time to time to know what a Clock it is at, consider well your Globe, in other pla- and find under what Hour-Circles the faid Places lye; as for Example, Suppose Rome lies under the tra Clock Hour-Circle, Constantinople under that of 10, Aleppo 9, &c. therefore the faid Towns towards the Limb of your Dials under the corresponding Hour-lines, and you will constantly know the time of the Day in the said Places; for calling it always Noon at each Place you feek after, you have nothing to do but to count the Hours from thence to the shade of the Stile; as v. g. If it be 4 a Clock with you in the afternoon, and you would know the Hour at Aleppo, let Aleppo be 12, and counting from thence (1. 2. 3.6c.) 'till you come to the Hour of the Day, (I mean the Hour then shown you by the Shade,) you will find it to be 7 a Clock there; for Aleppo is (you see) three hours Eastward of you now had the Hour with you been 4 in the morning, you must have counted backwards, as 11, 10, 9, 8, and consequently you would have found it there 8 in the morning. In this manner then you must operate all along.

To find the Suns place and day of the Month.

3ly. and 4ly, Find by your Globe exactly the Sun's height every hour at his Entrance into each Sign, then take by the help of your Setter (A B, the Erect Stile in Scheme 42. being Radius) the Tangent Complements of the Heights, and putting one Foot of your Compasses on your Dial at B, make Pricks or Marks in each corresponding Hour-line accordingly; that is to fay, if the Sun be high (suppose) so Degrees at 12 of the Clock, when he enters & or m, then take the Tangent of 40 and prick that distance in the Meridian line, viz. from B to f; and if his height at 1 and 11 a Clock be (v.g.) 48 degrees, take the Tangent of 42, and prick that distance in the 11 and 1 a Clock lines, viz. from B to b and g, and when you have gone thus o16

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over all the Hour lines, no fooner will the Sun come into & or IR but the Shade of the Point or Apex of the Stile A B will fall en very hour on the aforefaid Pricks, and confequently flow you the Suns place in the Ecliptic. In like manner you must do with the rest of the Signs, and then with the 10th Degree of eyery Sign, placing still the Character of each Sign about the Limb of your Dial, near the last mark or Prick belonging to it. This being done, fee by your Globe what day of the month corresponds with each Sign, and what with their Subdivisions. and if you mark this (as the faid 41th Scheme shows you) on . both fides of the Meridian, then the faid Pricks will (by the help of the Shade of the top of A B) show you also the day of the month. I mention here Pricks not only as an easier way, but a better way than Lines; for besides the great difficulty of drawing them, they embarras and confound a Dial very much, efpecially if there be many of them; whereas the faid Pricks are never out of an Hour-line, and consequently take up no new room. Now to avoid Confusion and Mistakes, I would have the faid Pricks of 3 forts at least, for if one Row were (v.g.) Aftericks and another Croffes, and a 3d Plain Pricks, you would then know at first fight, to what Sign or Day of the month any of them belongs.

gly. Instead of troubling you with deviding the Circle To find the GKLT (the upper part of the Border of the Dial) for the Rising and finding out the time of the Suns Rifing and Setting, you need Setting of only confult the Days of the Month on your Glabe, first, when He rifes earliest, Secondly, when He rifes at 4 a Clock, Thirdly, when at 41; Fifthly, when at 5; and in the like Proportion go on, till the Days come to their greatest Decrease, and putting the faid days of the Month in Order (as they are in the Scheme) under the corresponding Hours on the morning side of your Diel for his Rifing, do the like for his Setting on the Evening fide of it, and you may perform the Operation with sussignient Exactness. In like manner you are to proceed for the Quarters, half Quarters, &c. if you would have them exprest.

6ly. To avoid also the trouble of deviding the Circle To find the Au wo according to the Suns Diurnal Increment and Decre- Suns Ampliment in Amplitude, you need only find by your Globe, what the said Amplitude amounts to' on every of the aforementi ned Days (which are markt on your Dial for the Suns Rifing and Setting !

220 The Descript and We of the English Globe 9 5.

To find the Height of the Sun.

being the Radius) and putting one Foot on B describe the Circle X Y Z, afterwards describe another according to the Tangent of 35 Degrees, then a third, according to that of 40, and fo on in the same Proportion as far as your Plans permits. Now if you mark these Circles with the Figures of the Complement of their Degrees, that is to say the Circle of 28 Degrees with the Figure 62, that of 35 with 55, that of 40 with 50, &c., you will always know the height of the Sun, for what Circle so ever the Shade of A B touches with its Top, that will be the tequir'd Height; and if it falls between 2 Circles, 'tis but considering which of them it comes nearest to, and then you may guess at the Height with sufficient exactness.

To find the Suns Azimuth and Bearing. Bly, and 9ly. Devide one of these Circles viz. S E W N into Degrees, and under each 11 Degree and 4, place the several Points of the Pixidis Nautica, or Mariners Compass in the Order as they are expressed in our said Scheme, and you will not only have (by the Shade of A B) the Suns Azimuth at all times, but see also how he bears from you according to the Points of the Compass; and if the Shade be at any time too short, lay on it but a Ruler, Label of Paper or the like, and that will truly lengthen the said Shade, and resolve your Question.

To find the Proportion of Perpendiculars to their Shades.

many times as you can by the Stile or Radius A B, and then each Devision into ten equal parts (as you see it done in the said Scheme) and by it you will know at all times the Proportion between any Perpendicular and its Shade, and consequently, (besides many other things) the height of any Tower, Tree or the like; for having sound the Sun to be (suppose) 25 Degrees high, and that the Circle of Altitude cuts the Line A F in the 22 Devision, if therefore you measure the Shade of your Tower, and finding it (for Examples sake) to be 66 Tards long, you have what you seek; for as the said 22 is to 10 (the Stiles height) so is 66 the length of the Shade to 30 the height of the Tower.

desire all those that are pleased to sollow this Geometrical way (which perchance is as expedite a one, and as free from blind

Lines

now

Lines as can be,) not to rest satisfy'd till they fully comprehend what they do; for the Mechanical way of Dialling is as soon lost as learnt, it being impossible (without continual Practice) not to forget the Rules, especially if one can make many Dials; when as a man that understands the reason of the Operations (by having in his Head a true Idea of the Sphere and its Projection) will 20 years after without Memorandums or Notes, be able (restlecting but a little) to make not only all Dials he formerly knew, but new ones also at first fight.

To Conclude, I here present my Reader with the Globe in a new Dress, for being painted or stain'd on Marble (according to Sch. 43.) 'twill be fit for any Garden or open Portico; and least it might appear too plain, the corners of its Base or Pedestal may be adorned with handsom well turn'd Branches, which not only embellish the whole Machin by their Make, But hold out Bowls of Glass and Wyar for use also.

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For on the First Corner, to wit, That markt with A, there is The descriptiplaced (as a Rarity.) The blind man's * Dial. On the Second on of the Branmarkt with B. The Dial that shows the Hour, when the Sun shines ches or Embelnot, which will be often very useful. On the third, mark't with sheme 43. C, there is an Armillary Wyer Sphere having a Vane on the Top, that continually shows on the brass Plane within (graduated and * p. 111. Nautically Character'd) from what Quarter the Wind exactly blows; as also, (if you turn the said Vane into the Plane of the TP. 112. Sun) his Azimuth and Bearing. Besides, the Sphere (being an Horizontal Concave Dial) Shows the Hour too; for the Shade of the Pin's top in the Center ever fall's on the true Hour-Circle, as I show'd in the * Construction of such a Dial. And * vid. p. 113. by the way you must know this Branch stands not in it's true place in the Scheme; I mean on the third Corner of the Bafe, because in Perspective 'twill fall on the Globe it self, and confequently not appear well to the Eye in a Picture. Laftly, on the fourth Corner markt with D there is another Glas Bowl of the former Dimension, containing orderly all the Constellations, and remarkable Stars, and therefore, if you know the Hour, it will compose the said Bowl or Globe, and so represent the then position of the Heavens; but (tho you are Ignorant of the Hour) if you see a known Star, and move the Bowl on its Axis, till the painted star on it lyes just between your Ege and the Real one, Jon have the Hour, and consequently may know (the Globe being

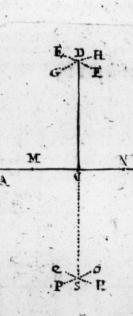
F. Moxon To the Reader.

Having Courteous Reader * engaged to show you the Problems and Operations on the Sector, which the Noble Author supposes every one (that studies the Geometrical way of Dialling) to know, I shall here begin.

I. Upon a Line given (AB) to erect (CD) a Periendicular.

If there be a Point (as C) given in (AB) the Line on which the Perpendicular is to fall, Mark on both sides of the said Point (with your Compass) the equidistant Points M and N, then opening them at pleasure, put one soot on M and describe the blind Arch EF, and putting the other Foot in N, describe the blind Arch GH, and the sair line from (D) their Intersection to the Point C, will be the Perpendicular required. Now if you have no Point assigned (in the said Line (AB) to terminate your Perpendicular by, take two Points there at pleasure, as suppose M and N, and opening how you will your Compasses, describe the blind Arches EF and GH above your Line, and OP and QR below it, and the Intersections

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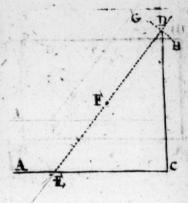


The same of the

tersections of these Arches (to wit, D and S) will be two points to draw your Perpendicular by.

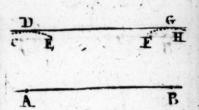
II. Upon (C) the end of (AC) a given Line, to dram.
(DC) a Perpendicular.

OPEN your Compasses at a convenient width, and putting one Foot on C, let the other (within reach of AC) mark any where, as at F: then touching or cutting from thence the said AC (with the moving Foot of your Compasses) at, suppose, E, and describing on the other side of F the blind Arch GH, lay your Ruler on FE, and it will cut the said Arch, at, suppose D, so that DC will be the requir'd Perpendicular.



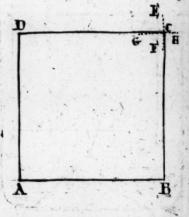
III. A Line (AB) being given how to draw (DG) a Pa-

HAVING taken two points in the said Line, as suppose A and B, open your Compasses at what width you please, and putting one foot on A, describe the blind Arch CDE, and putting one foot on B describe the blind Arch FGH, then if you lay your Ruler on the highest part or greatest Extuberancy of the said Arches, to wit on the Points D and G, the Line so drawn will be the required Parallel.

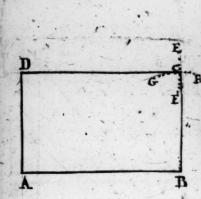


IV. To describe a true Square.

A B being a Line as long as the side of the Square you design, erect on the end A, the Perpendicular, D A of the former length; then taking between your Compasses the said A B, put one foot on D, and describe the blind arch E F, and again putting one foot on B, describe the blind arch G H, to cut E F, and if from their Intersection C, you draw the sair lines C B and C D, you have a true Square.

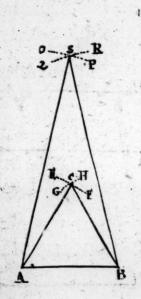


V. To draw an Oblong, or (as they commonly call it)
a Long Square.



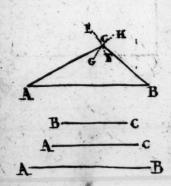
A B being the longest side of this Square, erect on the end A, the Perpedicular D A, of the length of the shortest, then taking between your Compasses, the line A B, put one foot on D, and describe the blind arch E F; and taking between your Compasses the line A D, describe the blind arch G H, to cut the said E F, and if from their Intersection C, you draw the fair lines C B and C D, you have the Square you design.

VI. To Describe an equilateral Triangle, or an Isosceles.



OPEN your Compasses at AB, being the side of the Triangle you design, and putting one soot on A, describe the blind Arch EF, and again putting one soot on B, describe the blind Arch GH to cut the said EF, and is from their Intersection C, you draw the fair lines CA, and CB, you have a true equilateral Triangle; Nor is there any difference in the Description of the Isosceles ASB, for the only difference between them is, that the sides AS and BS of the Isosceles are longer (or if you please they may be shorter) than the Base AB, whenas all three sides are equal in the equilateral Triangle.

VII. To make a Triangle of three given Lines.



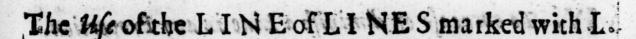
SUPPOSE the first line given be A B, the second A C, the third B C, and that you are to make a Triangle of them: let A B be the Base, and taking the given line A C between your Compasses, put one foot on the Base at A, and describe the Blind Arch E F, then taking the given line B C, between your compasses, put one foot on the Base at B, and describe the Blind Arch G H, to cut the said Arch E F, and if you draw lines, from their Intersection at C, to A and B, on the aforesaid Base, you have your intent.

VIII. To describe an Oval.

ROSS R Patright Angles with I M, and taking with your Compasses (on the said lines from the intersection O) equal diftances, to wit, O A, O B, O C, and O D, and draw through the point C, the lines A K and B H, each equal to twice A C, as also throu' D the lines AN and B L, each equal to twice B C, then A and B being Centers, describe the Arches K P M, and HLR; in like manner C and D being Centers, describe the Arches HIK, and L M N, and the figure thus drawn will be a

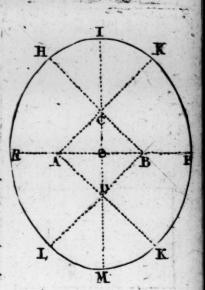
perfect Oval.

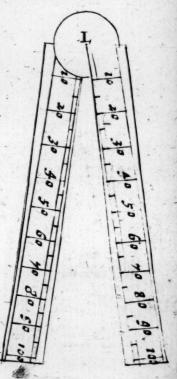
So much for the Geometrical Problems necessary for Dial- Of the Sector ling, and as for the Instrumental ones, i. e. those performed by the Sector, they are, as I may fay, of two forts, some belonging to one side of it, and some to the other; for the side marked with L is divided into 100 equal parts, and called the LINE of LINES, and the fide mark'd with S, the LINE of SINES: First then of the LINE of LINES, which by the way, tho' itbe divided (as I faid) but into 100 parts, may yet stand for 1000, if you fancy every 10 Divisions a Line of 100 parts, and in like manner it will stand for 10000 parts, if every division be deemed 100, therefore a Line (vg.) of 75 equal parts, may be exprest by 75 of those Divisions, or by 7 tor by 1.



I. To divide a Line into any number of equal parts.

CUPPOSE your Line were to be divided in 23 equal parts, I take it between your Compasses, and opening your Sector, place one foot of your faid Compasses on the 23 division of the Sector, and the other foot on the 23 over against it, and the distance between the Figures 1 and 1. on the faid Sector will give you one equal Division of your Line, and the distance between 2 and 2, will give you two equal Divisions of it, and in this manner proceed till you quite run over it, as you design.





II. To find the proportion between any two Lines.

SET over the greater Line at 100, and 100 on the Settor, then taking the lesser between your Compasses, find where it will be just set over also, or lye parallel to the former, which happing suppose at 50 and 50, you may conclude, that the Proportion required, 15 as 100 to 50.

III. To divide a Line as any other Line proposed is divided; that is to say, according to any Proportion.

Suppose you saw a Line, containing 65 equal parts of the Sector devided into three pieces, the first containing five equal parts of the Sector, the other fifteen, so that the last must be 45; then suppose you would divide (after this proportion) another Line, containing but thirteen equal parts of the Sector; Open your Compasses at 13, or length of the Line to be devided, and putting it over at 65, and 65 on the Sector, the Parallel at 5 and 5 will be the first division of the Line to be divided, and one equal part of the Sector in value; the Parallel at 15 and 15 will be the second, and three equal parts in value; and the remainder (being 9 in value,) will be the third; and thus you may do in all other cases.

IV. To encrease or diminish a Line in any Proportion.

Suppose the Proportion were as 4 to 7, take the Line given between your Compasses, and setting it over on your Sector, at the Figures 4 and 4, the distance from 7 to 7 will be a Line encreast (in respect of the given one) as is the Proportion of 4 to 7; In like manner you must do, if any other Proportion were required.

Now if you would diminish a Line as is 7 to 4, put over the Line given at 7 and 7, and the distance of 4 and 4 is the requir'd proportion.

V. Two Lines being given, to find a Third Proportional.

TIND by your Compasses how many parts of the equal Divisions of your Sector will measure both your given Lines, fo that supposing the one to contain 10 parts, and the other 20, fet the second Line (i.e. the Line 20) over at 10, and 10 on the Sector, and the distance or Parallel at 20, and 20 on the Sector will be 40, the requir'd Proportional.

VI. Three Lines being given, to find a Fourth Proporti-

THE value of the Lines being found as before, and supposing the first to be 10, the second 20, the third 30, put over the second Line (to wit, 20) at 10 and 10. (the value of the first Line) and the distance or Parallel at 30 and 30. (or value of the third Line) will be 60, the required Proportional.

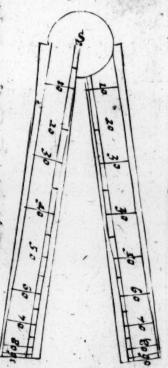
Of the Use of the LINE of SINES, marke with S.

I. How to find the Sine of any Angle, according to any Radius.

CUppose the Sine of the Angle you require be 50, take the Radius between your Compasses, and put it over at the extremity of the Sector, that is to fay, at 90 and 90, and the Parallel at 50 and 50 will be the Sine of 50 Degrees, according to that Radius.

II. How to find the Chord of any Arch.

CUppose you would have the Chord of an Arch of 50 Degrees, open your Compasses at the length of the given Radius, and put it over at 90 and 90, then take with your faid Compasses the Parallel, at the Figures 25 and 25 on the Sector, (i.e.



III. How to make an Angle of any value, as also how to find the value of any Angle already drawn.

Supplement, viz. EBA will be the Angle of you Degrees, draw a Supplement, viz. EBA will be the Angle of so as before, and the Angle of its Angle of its Angle of so, as before, and the Angle of its Supplement, viz. EBA will be the Angle you look for:

Here therefore you see how to find the value of any Angle already drawn, as suppose the Angle EBC, since 'tis but describing a blind Arch, as CF, and setting over (on the Sector) the Radius of the said Arch at 90 and 90; for if you observe where the measure of this Arch (viz. C.E) marks a Parallel on the Sector, as before, the Figures there (to wit, 25) being doubled (and amounting consequently to 50) will be the requir'd Angle.

As for the Tangent and Secant of any number of Degrees, the Noble Author has himself showd you how to find them at pag. 71. and so gentle Reader having finish'd my promise, I bid you Farewel.

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SECT. VI.

Of the STARS.

As for the Stars, it is not my set business to meddle with them, nor is there any Instrument that so naturally refolves all the usual Questions concerning them, as the Cale-stial Globe; for there things appear as they do in the Heavens themselves; But because such a Globe is not always at hand, I will shew you how its most necessary Operations may (in case of necessity) be performed, even by our present Globe, and then I shall treat of the Pedestal, on which all the appearing Stars are truly projected.

The usual and most necessary Operations of the Coelestial Globe in relation to the Stars are these.

1. To find the Declination of any Star.

2. To find the Right Ascension of any Star.

3. To find the difference between the Suns Right Ascension, and that of any Star, or the difference between the Right Ascensions of any two Stars.

4. To find the true place of any Star on the Globe, i.e. the Point that corresponds there, with its then Place in the Hea-

vens.

5. To find the Bearing of any Star according to the Points of the Compass.

6. To take the height of any Star you see:

7. To find the height of any Star by the Hour tho' unseen.

8. To find the Azimath of any Star.

9. To find how many Hours any Star stays above or below the Horizon.

10. To find when any Star rifes or fets.

11. To find what a Clock 'tis by any Star.

12. To know the name of any Star you fee.

OPERATION I.

To find the Declination of any Star.

A Sfor the Declension of the Stars, since the Calestial Globe and other Instruments, that shew their motions, perform this Operation by their make (for on them the Stars are always plac'd, according to their respective Declensions) we shall require here a proportionable Concession, viz. That in some of the vacant parts of our Globe there may be a little Table, containing the Declension and Magnitude of the most noted Stars, as also the Degree of the Ecliptick, which agrees with their respective Right Ascensions: that is to say, a Table containing their Declension and Magnitude, with the Suns Place in the Ecliptic, when his and their Right Ascension are the same; and the said Table may be made in the sollowing manner.

The Table for the Stars.

Mag.	Name.	Declension, Deg. Eclip.
	Bulls Eye.	15 48. II 6.
. 11.	Lions Heart.	13 33. 0 26.
1.	Arcturus.	SI 4
.0.2.	Little Dog.	6 3. 519.
2.	Medufa, or Alg	ol. 39 40. 813.
And fo	for as many as th	ne Globe maker thinks fit to express.

OPERATION II.

To find the Right Ascension of any Star, veg. of the

Having found by the Table, that the Lions Heart has the same Right Assension with the Sun, when he is in the 26 of St., draw your String over that Degree of the Ecliptic, and it will cut the Equator at almost 148 Degrees, for the Stars Right Ascension.

OPE-

OPERATION III.

To find the difference between the Suns Right Ascension, and that of any Star, as also the Difference of the Right Ascensions of any two Stars.

Having found by the former Operation, that the Right Afconsion of the Lion's Heart is towards 148 Degrees, and that
the * Suns (on v.g. the 10 of April) is near 28, the difference Sect. 1.
(by Substraction) will appear to be about 120 Degrees, or (by pag. 19.
the intermediate Hour Circles) 8 hours. In like manner having found (for example sake) the Little Dogs Right Ascension, to be about 110 Degrees, the difference between it and
that of the Lions Heart is 38, or 2 hours and a half.

OPERATION IV.

To find the Place of any Star on the Globe, i. e. the Point that corresponds with its then Place in the Heavens.

Having found by the foregoing Operation, that the difference between the Suns Right Ascension and the Lions Heart, is about 120 Degrees, or 8 hours, substract the said hours (for so much the Sun Rises and Sets now before the Star) from the time given (suppose from 10 at Night) and the remaining 2 hours shows you, that the Star is at that moment in some part of the Hour-circle of 2 in the afternoon, or thereabouts; so that the Bead rectify d to the Stars Declension, and moved on its Noose from the Pole to the said Hour-Circle, determines the very Point or Place required, The like may also be performed by your Compasses open d from the Pole, at the Complement of the Stars Declension.

But here you must remember that the readiest way still to A Memoranfind the present place of a Star is by its Almucantar and Azi-dum. muth; for where these Circles intersect, there-the Stars then Place will be; and as for the Almucantar and Azimuth of any Star, they are sound by the 6th, and 8th, Operation of this Section.

Section.

OP E-

To find the Bearing of a Star at all times.

Having found the true Place of the Lions Heart by the former Operation, if you draw your String over it from the Zenith, 'twill cut the Horizon at or about S.W. for its then Bearing.

OPERATION VI.

To take the Almucantar or height of any Star you fee.

B Ecause Stars cast no shade, you must take their Height as you do the Suns when he is overcast, and therefore consult the first Operation of the first * Section, or the 5th, of the *4th. Section.

*p. 68.

OPERATION VII.

To find the beight of a Star at any time, by the hour tho' un-

THE Hour being (v.g.) 10 at Night, on the 10 of April, the Suns place is where his Parallel cuts the 10 a Clock Hour Circle, so that knowing by the difference of their Right Ascensions that the Lions Heart is (v.g.) 8 hours behind the Sun, you may conclude the Star to be somewhere in the Hour-Circle of 2 in the asternoon, to wit, in that Point, which answers to the said Stars Declension; having therefore its Place, draw but your String from the Zenith over it, and mounting your Bead to it, if you move your said Bead to the Meridian or Quadrant of Altitude, 'twill lye on or about the 45th. Degree for the required Height.

OPERATION VIII.

To find the Azimuth of any Star.

Find but the Lions Heart's Bearing, or his then true Place in the Heavens as before, and the String will cut the Horizon on its true Azimuth. Now if you fee the Star, you may perform this Operation without any of the former Postulats; for placing your Globe on a Meridian Line, and holding your String streight from the Zenith, do but move it in that posture by the direction of your Eye (as we show'd you in the first *Section) till it be in the same Plane with the Star, and the *Op.5.may 2. Degrees of the Horizon under your String, give you the re-p. 10. quired Azimuth, which will now be about 45 Degrees Westmard.

OPERATION IX.

To know how many bours any Star stays above or under the Horizon.

Rectify the Bead to the Declension of the Lions Heart, and moving your String on the Noose from the Pole, till the said Bead touches the Horizon on the West side, see what Hour-Circle cuts with it there, and you will find it to be that of 7 and a quarter or thereabouts; and this doubled (making in all some 14 bours and a half) gives the true time of its stay above the Horizon; so 4 and three quarters doubled (I mean the Hour-Circle which Intersects with it on the East side) gives. You 9 hours and a half for its stay below the Horizon.

OPERATION X.

To find when any Star Rises or Sets.

Having found by the third Operation, the difference between the Suns Right Ascension and that of the Lyons Heart to be 8 hours on the 10th of April; and having also found by the fore-

The Wescript and we of the English Globe. 9 6 134

foregoing Operation, that it Rifes where the Hour-Circle of 4 and 3 quarters cuts the Herizon, and Sets where that of 7 and a quarter do's the like, add the 8 hours difference (because the Star is now so much behind, or too flow for the Sun) to 4 and 3 quarters, which making 12 and 3 quarters in all, shows that the Star rises at 12 a Clock, and 3 quarters in the afternoon; and by adding it to the aforesaid 7 and a quarter, that it fets at 15 and a quarter, to wit, at 3 and a quarter in the morning.

OPERATION. XI.

To find what a Clock 'tis by any Star.

HAving (v.g.) on the 10th. of April found the true place of the Lyons Heart, on the Globe, by some of the former the Lyons Heart, on the Globe, by some of the former ways, as (for Example) by its Height and Azimuth: I fay; having thus found the Stars true place on your Globe (which hapning (v.g.) to be in the 2 a Clock Circle) find by the third Operation the difference between its and the Suns right Ascension, which being 8 hours, add it to the said 2 (for the Star is as we said 8 hours now behind or too slow for the Sun) and the then true hour will be 10 at night.

OPERATION XII.

To know the Name of any remarkable Star which you fee-

BY a Stars Height and Azimuth you may (as we have show'd you) quickly find its present true place on the Globe, and consequently its Declension, as being the nearest distance between its said Place and the Equator; so that your Tables of Declention gives you its Name; and if there should be two of the same Declension then their right Ascensions (being different) will resolve the Doubt.

To conclude, all the former Operations may be jet more readi-A Memoran- ly performed, and that without any Table, if the Globe-maker place 10 or 20 of the most noted Stars (which will be enough to

satisfy any ordinary curiosity) on the Globe it self, according to their true Longitude and Latitude; for then their Declensions, Parallels, and right Ascensions appear in a manner at first view, which must needs therefore facilitate the other Operations.

of the PEDESTAL.

THIS you fee that our Globe (tho' it be a Terrestial one) may (in case of necessity) be serviceable in relation to the very Stars; but because all Operations that have the least Reflection in them, feem intricate and troublesome to some, I have here adjoyned (for them that will be at the Expence of the best fort of these Globes) a most Facile way, that shall refolve in an instant, all the former Questions and more; for thereis not only a Steriographical Projection on the Pedestal of the appearing Stars in our Horizon, but one also so ordered, that it obviates the inconveniences which make Stofflers admirable Astrolabe so much neglected of late; for some say, there is no finding a Star en it without much poring, tho' we should know near what Constellation it lyes; others, that when we see a Star there, we are still ignorant to what Constellation it belongs; maby quarrel at the great confusion which the Azimuths, Almucantars, and other Circles exprest on it make; and some again. object, that the numeral Figures belonging to the faid Circles are oftentimes so hid by the solid part of the Rete, that we cannot without a new trouble and motion perform the intended Operation. I say, this Projection on the Pedestal (besides several other things) obviates these inconveniences, as you will presently see.

The Explanation of the Circles and Lines of the whole Projection or Pedestal.

THE uttermost Circle (in Sch. 1) or Limb S E N W of the Of the first lower or first Plane, represents Circulum maximum sem- bigness. per latentium, or (if you think that too large) what Parallel you It may be conveniently nine Inches or a little more in Diameter, if the Globes be a Foot, and being of fine Pastboard or the like substance, it is to be let into the Pedestal, which:

which is purposely made Cradle or Frame wife, that it may (by your hand underneath) be easily turn'd round, and be also taken quite out, if any particular or extraordinary occasion should require it; Nay, the whole Pedestal may be pulled off, (if you think fit) from the handle or Fulerum, and us'd apart as a distinct Instrument.

Of the Circles it, and bons they are pla-

2. The great Circles described on it are only two, viz. the and Stars on Aquator (V E = 2) and the Ecliptic (F 5 = 19) divided into the 12 Signs, with their gradual subdivisions. Now (fince it will be no incumbrance to your Plane) you may express on it also (if you please) the two Tropics, by two fine Circles, that of Cancer touching the Ecliptic at 5, and that of And as for the Limb, it is divided in-Capricorn at 19. to 360 Degrees, for being in Projection greater than the Aquator, 'twill prove more useful in all the Operations, that concern fuch Divisions. Nor are the Circles or Stars placed here as on the Globe (I mean according to the Degrees of a Quadrant equally divided) but Steriographically projected by half Tangents, i.e. as they would appear and fall on an Aquinoctial Plane, or a Plane parallel to it, were our Eye in the Pole, of which more hereafter, as also the Centers and Radius's of each Circle, when we come to the Description and Demonstration of the whole Projection; and in this manner also (to wit, by half Tangents) the Line P. E. is divided, which shows the Declenfion of any Star.

> Thirdly. The Stars being all plac'd on this Plane according to their respective Right Ascensions and Declensions; and by the way, when you once know how to find by this Proje-Stion the Right Ascension and Declension of a Star (as you will prefently do by the following Instructions, that concern operation) you will then also know by the help of Astronomical Tables (which give each Star's Right Afcension and Declension) how to place them here: Isay, the Stars being all plac't on this Plane, according to their respective Right Ascensions and Declensions, they are to be Marshall'd and reduc'd into Constellations; and therefore you must suppose either fit Pictures drawn about them to express what they are, or that the utttermost Stars of each be join'd by a fine Prick't Line, which will give you perchance, the most clear and just representation of them, and consequently prove the

> > easiest

easiest way for the sinding them out in the Heavens; But since Pictures have conveniencies and great ones also; for thus without consulting the written names, we cannot only find presently (even a far off) the Constellation we seek after, but know at the same time the Place of each Star in it, which Place for the most part gives the Star its ordinary Name: I say, since Pictures have great Conveniences, let them be us'd; but then they must be as faintly and simply express'd as can be; for deep shadows, and unnecessary Flourishes both distract the Fancy, and cause even the Stars that are express'd to be less conspicuous and observ'd.

Fourthly, When the first Plane is thus garnished and plac'd Of the second in its Frame, there is another of the same bigness, either of Plane, and it's Glass, or Talk (represented by Scheme the second) to be put bigness over it, and fixt or sastned in the uttermost Molding or

Ledge of the Pedestal. And here be pleas'd (for distinction sake) to remember, that by the Terms First, and Second, these two Planes are distinguish'd, and that by Projection is meant the whole Pedestal, or Astronomical Machin, which (as I said) may be taken off, and used apart, as a particular In-

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Lastly, the second Plane (represented, as I said by Scheme the second) has its Limb S. E. N.W: divided (besides the subdivisions or Quarters) into 24 equal parts, by so many streight Lines, drawn from the Center P, and figur'd (I. II. III, &c.) according to the hours of a natural Day. As for the Circle HRS T, it represents the Horizon; and the Circular Pricks within it give the Almucantars and Azimuths of every 10 Degrees; for (on the one fide) if you confider the said Pricks as so many Circles ascending from the Horizon towards the Zenith, the Figures along the Lines, PS and PN give you from the Horizon upwards the height of that Star which touches any of them. On the other side, if you consider them in File, (I mean as to many Arches pasfing thro' the Zenith, and terminating in the Horizon) their distance from PS (the Southern part of the Meridian) shows the Azimuth of the Star next any of them, by the Figures round the Horizon; and least you might not readily distinguilh Arch from Arch, if the Pricks were all of the same kind or Species, there are two forts here, viz. one of plain an d

plac'd; so that 'tis but observing of what Species the Prick next a Star is, (as suppose an Astrisk,) and then sollowing with your Eye a File or Arch of Astrisks' till you come to the Horizon; for the Figures at their termination there give you the requir'd Azimuth. Thus then the consussion which the several Almucantars and Azimuths would make (were they all describ'd on the Plane) is avoided, seeing the Plane is now less sill'd than if the Almucantars were only exprest on it; for disjoyn'd Pricks circularly plac'd occupy not the room of a continued Circle, and yet each Row or Circle of the said Pricks perform both the forementioned Offices.

How to operate by the Projection or Pedestal.

EIRST the Reader must remember, that I call Restissing the surface; the placing and adjusting it so that all the Stars may appear above and below the Horizon, as they then really do in the Heavens themselves; which Operation being a main and principal matter (for all the other are in Truth but so many Deductions or Corollaries) I will now begin with it; nor is there any thing here required but the height of some Star in view (as the Lion's Heart, or the like) which you may find by the Globe as you do the * Sun's or † Moons height as I mentioned * before. Now for cleerness sake, let us suppose this Star to be about 45 Degrees high Westwardly, and then if you move your Plane till the said Star, lyes thus under a Prick of this height, you have (without ever moving more the Plane) the several sollowing Operations at a time.

First, You see all the Stars that are then above the Horizon and below it; for all the painted ones within the Circle HRST, on the second Plane represent the real ones then in sight, and the rest those that are below the Horizon. Secondly, You see what Stars are Rising, what are Setting, what are Culminating, and what are in their Lowest Depression. Thirdly, If you look after any particular Star (suppose the Lion's Heart) by seeing him on the West-side of PS (the Meridian of the said second Plane) you are sure he is not on-

* p. 6. † p. 68. * p. 132.

ly in a Declining state but also (by following the Prick next him to the Herizon, according to its Species) that his Azimuth is 45 Degrees. Fourthly, You will fee his Bearing, to be about S. W. if you follow the Azimuthal Arch to the Nautical Characters there. Fifthly, You see that the Hour of the Night is 10, by observing under what Hour-Line the 10th. of April (i.e. the day of the Month, the Suns place in the Ecliptick) lyes. Sixthly, By any real or imaginary HourLine that runs over the faid Star, you find his Right Ascension to be near 148 Degrees; for thus the said Hour Line cuts the Limb. Seventhly, By his being behind the Sun about 8 hours (as appears by the Hour Lines that pass over the Star and the Suns place) you have the difference of their Right Ascensions, which amounts to about 120 Degrees. Eighthly, Which is the most surprifing (and not performable even by a Cælestial Globe) you no sooner see these things in relation to this or any other particular Star, but at the same time also (even without touching your Projection) you have them in relation to all the Stars in general; for when the First Plane is rectify'd, we have (besides the Hour) the Heighths, Azimuths, Bearings, Right Ascensions, &c. of all the other Stars above the Horizon.

Concerning the other Operations, they are more restrain'd, as being peculiar to the Star you enquire after; for if you would know when the Lions Heart Sets, (which for continuation's sake we will call the ninth Operation) do but move your first Plane till the said Star touches the Horizon, and the imaginary Hour Line that passeth over the Sun's place in the Ecliptic, show's you, that 'twill be then about 3 and a quarter in the morning.

soly. By the Figures about the Horizon, you will see at the same time, that his Occasive Amplitude is near 23 Degrees Northward, and his then Bearing (by the Nautecal Caracters) to be WNW, or thereabouts.

11. By the imaginary Hour-line that then passes over the said Star (viz. that of about 7 and a quarter) you have half the time of his constant aboad above the Horizon, and consequently know, that from his Rising to his Setting there are about 14 hours and an half.

12. By reason that the imaginary Hour-line of about 7 and a quarter passes over the Star (as we said) at his Setting, it sollows that it's Ascensional difference (i.e. the difference between its

Right .

Right and Oblique Ascension) is about an Hour and a quarter, or 18 Degrees.

(which is the 26 of Ω) and by the opposite Degree which then Rifes (vi7, the 26. of ∞) you see that on the 8th. of August he Sets Achronically, and on the 2. of February Cosmically.

14. Remove the said Plane, till the said Star brushes the Horizon on the East-side, and by the precedent method (mutatis mutandis) you will find when he Rises, what his Ortive Amplitude is, how he then Bears, how long he is under the Horizon,

when he Rifes Cosmically, and when Achronically.

Class over the Lions Heart, and then moving the first Plane, till the divided 6 a Clock Hour-line P B, lyes just under the said point the Divisions there will show its Declination to be about 13 Degrees and 33 Minutes. The like you may do with your Compasses; for if you take the Distance between the Pole and Star, and measure it on P E, you have what you seek for.

Many other Operations are performable by the Projection. touching the Stars; but fince these are the most material ones, and fince I have not time to treat more fufely, I leave the rest to be found out by my Reader-himself, who may easily do it, if he understands either the Calestial Globe, or any Instrument belonging to the Stars. And here he is to remember, that knowing but the Hour at any time, let him put the Suns place, or day of the Month under the Hour-line, that corresponds with it, and the Projection will be rectified, and confequently (having a true view of the then posture of the Heavens) he may opperate as before. In the next place, if he knows but the Suns place in the Ecliptic of the first Plane, and opperates with the said place as if it were a Star, he may find out the former Operations in relation to the Sun it felf; that is to fay, be may at that moment know his Height, Azimuth, Bearing, Amplitude, &c.

also do it by the help of this Projection; for your first Plane being restified, it gives you (as I said) the true poslure of all the Stars; so that if those you seek after be near the Horizon, Meridian, or any other noted Quarter, those on your Plane

Two Memo-

near its Horizon, Meridian, or corresponding Quarter will resolve the Question. Or, if you take the beight of a Star, and its Azimuth (according to any of the former Directions) then whatever Star on your Flane has the same, it will be that you feek after, and confequently you have its Name. Now knowing once a Star, your faid first Plane shows you what they are that lye about it, and so by degrees you may run from one to another round the Heavens. Nor need you, as to the knowing of the Stars, be so exact (either in rectifying your Projection, or in having the hour of the night, or in taking the Heights, and the like) as in other Operations: for, by the biggers of the Star, py its nearness to some remarkable one, and by twenty other barticular properties, you will be so regulated and confined, that you may fafely conclude, when you examine your Projection, that the real Star you see, can be no other than such and: fuch a one.

How to Describe the PROJECTION.

Having thus show'd you the use of the Pedestal or Projection, I shall fall on the way of Describing it, and (according to my manner all along) on the Demonstration of it also, especially since it conduces to a more easy comprehension of all Steriographical Projections; and if I be a little longer than ordinary, it is now no great matter, for I have ended all the Operations I intend at present, so that what is here surther said may be omitted without inconvenience, if the Reader be disgusted at Speculation.

As for the nature of the Projection, tis Optical, representing The Principle all things in the Heavens, as they appear to the Bye, from such on which this and such a Station, and not according to their true and real Projection dedistances. 'Tis chiefly founded on the 20th. Proposition of the Pends. third Book of Enclid, which proves, that the Angle at the Periphery is but \frac{1}{2} that at the Center; for from thence 'tis infer'd, that if placeing our Eye on the superficies of the Sphere (v. g. at the South Pole) we look into its Cavity, the Angle made at our Eye, by the two Rayes that issue from it (the one along or throu' the Axis to the opposite Pole, and the other to a determined Point) will be the Angle only of half the value of the Arch, orreal distance between the two Objects, i. e. between the

faid.

142. The Weitript, and the of the English Globe, § 6.

faid Opposite Pole and Point; now since any Diameter on the Plane of the Æquater (for that, or some Parallel Circle to it, we now suppose to be the Plane of our present Projection) meeting with those Rays, will be the Tangent of the Angle they make, which being in value (as we said) but half the real distance between the said Objects, it must need follow, if any Star or Point in the Heavens be distant from this opposite Pole, suppose 20. Degrees, That the Tangent of 10 Degrees from the Center of the Projection (which represents the said Pole) gives its true appareent place there, and the like is to be said of any other distance.

Ishall not trouble the Reader with any Scheme to demonstrate this further, because (being sussely treated of by Aguilonius and others) 'tis obvious enough to all Mathematicians; and as for new Beginners (if they desire a suller conception of it) let them but apply themselves to any man vers't in Projections, and in the space of ten Minutes he will shew it them more clearly and naturally, by Strings sitly placed on an Armillary Sphere, than I can here in many hours; therefore supposing (if to such, what I have already said be not evident) that the Heavens may be thus projected by half Tangents, let us proceed to the way of doing it, that is to say, to the finding of the Canters and Radius's of all the Circles which conduce to the before mentioned Operations.

Of the Concentric Circles.

As for the Concentric Circles of the first Plane, to wit, the Aguator, the Tropics, and the Limb, which is (as I said) Circulus maximus semper latentium, or some Parallel to it, there is no difficulty in describing them; for having drawn at right Angles the Lines NS and EW (representing the four Cardinal Points) throu'P, the Center, or projected Pole, if you open your Compasses at the Tangent of 45 Degrees, and place one foot on the said P, you must needs project the Aquator; because being diftant from either Pole 90 Degrees, the Ray that touches it, and that which runs along the Axis to the opposite or North Pole, makes an Angle at your Eye (as we faid before) of only half so much. In like manner, the Tropic of Cancer being 66 g. 30 m. from this Pole, the Tangent of 33 g. 15 m. gives his Radius, as the Tangent of 56. g. 45 m. does Capricorn, whose real distance from the said Pole is 113 g. 30 m. for it lies 47 Degrees beyond the former

Tropick. And lastly, the Tangent of 64 g. 15 m. projects the Limb or uttermost Circle, if it be Circulus maximus super latentium, as being yet is Degrees further; for the true distance of that Circle from the faid Pole 128 Degrees and 30 Minutes.

Now for the main matter, to wit, the great Circles which fall The general obliquely on the Plane, take this easy general Rule for them all, jecting the viz. That the'r Centers are distant from the Center of the Pro-great Oblique jection the Tangent of as many Degrees as their Poles are di- Circles. stant from the Pole of the Plane, on which the Projection is made (that is to fay, in our present Case, from the North-Pole of the World) and the Secant of the faid Darrees is their Radius.

Suppose then you were to project (v.g.) the Ecliptic, which Of projecting is the only oblique Circle of your first Plane; you know that its the Ecliptic .. Northern Pole, (being in your Meridian) is distant from the North Pole of the World 23 g. 30 m. Open therefore your Compasses at the Tangent of those Degrees, and place one Foot in P, and the other will give you in the Line PN (the Northern half of the Meridian of your Plane) or in the Line PS, (the Southern half of the said Meridian) the point D, for the requir'd Center. D then being the Center, open but your Compasses at the Secant of the said Degrees, and you have the Radius; Nay, the D. stance from D to e, or from D to w, the East and West Points of the Aquator (or points where the Ecliptic intersects with the Aquator on the Sphere) gives this. Secant; for if P D be the Tangent of 23 g. 30 m. then De and Dw are (you see) the Secants. But before we demonstrate the aforesaid Rule, let us make an end with the great Oblique Circles of the Transparent or second Plane, which are only the Horizon HRS T, and the Azimuths of every 10 Degrees, exprest (as I faid) by plain Pricks and Astrisks.

As for the Pole of the Horizon, it is (you know) the Ze- Of projecting nith, which being distant in your Meridian 38 g. 30 m. South- the Horizon. wards from the North Pole of the World, it must follow by the former Rule, that the Tangent of 38 2. 30 m. (or Complement of the Elevation) from P (the Center of the Projection) giving you (Southwards in the Meridian of your Plane) b, the requir'd Center, the Secant of these Degrees will be the requird Radias. Nay the distance from b to e, or from b to w

the East and West points of the Equator, (or Points where the Horizon cuts the Aquinoctial Colure) gives this Secant; for if Ph be the Tangent of 38g. 30 m. he and hw are the Se-

Of projecting cants. the primary Vertical

The Poles of all the Azimuths, are (as every body knows) in the Horizon; now that of the Primary Vertical, being in the Meridian also, 'tis distant in the Heavens (on the North fide of your Meridian) the value of the Elevation, or \$1 g. 30 m. fo that by the foregoing Rule (PV) the Tangent of those Degrees will, from the Center P (Northward,) give you in the Meridian of the Plane the Center of this Circle, and the Secant the Radius. Nay, the distance from V to e, or from V to w, the East and West Points of the Equator, (or points where the faid Primary Vertical cuts the Aguinostial Colure) gives this Secant: for if P V be the Tangent of 51 g. 30m. Ve and V w are the Secants. Belides, where the moving foot of your Compasses (thus extended) touches the Meridian of the Plane, there will be the Zenith in projection, and consequently distant from P (Southward,) the Tangent of 19 d. 15m. or half the Complement of the Elevation; for our Zenith lyes in the Meridian 38g. 30 m. beyond the Pole on the South-side of the Sphere or Heavens.

Of projecting Azimuths.

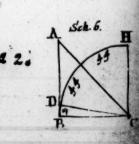
As for the Centers of the other Azimuths, tho' there be no the rest of the Tables calculated to shew how their repective Poles are distant from that of the Plane or Projection, and consequently the aforesaid Rule may seem useless, yet by resolving a Triangle, these Distances may be found, as also the value of the Angle, made by your Meridian (or 12 a Clock hour Circle) with the Meridian that passes throu' the proposed Degree of the Horizon, so that the Rule serves as before; for if you draw a blind Line thro' P, that makes an Angle with P N, answerable to the value of the Angle of those two Meridians in the faid Triangle, the Tangent of the distance found between the Pole of the Plane and that of the propos'd Azimuth will still give you its Center from P in the faid blind Line, and the Segant its Radius.

But you may avoid the Resolution of a Triangle, by the usual An expedite may of finding expedite way, viz. by drawing thro' V (the Center of the Primary Vertical, found as before) the blind Line K. M. at Right sbe faid Conters and Ras Angles with P. N. (the Northern part of the Meridian of your dins. Plane) Tlane) and then pricking on both sides of the said V (ZV being Radius) the Tangents of all the Azimuths you would express, as (for example) those of 10,20, 30 Degrees, &c. for the said Pricks give their Centers, and the Secant of those Deg. their Radius. This Way also agrees not a little with the above mentioned Rule; for if the distance from V (the Center of the primary Vertical) to 10 (the Center of the Azimuth of 10 Degrees) be the Tangent of those Degrees, 'tis evident, that the Radius Z 10 is the Secant; and if this be the Secant, the distance from V to 10 is the Tangent. Thus then in short may be drawn (mutatis mutandis) all other great oblique Circles in any Steriographical Projection, when their Poles lye in one and the same Circle; and now fince the aforesaid Rule agrees even with this usual way of describing these Circles, I will here Demonstrate it, having done with the great Circles on both our Planes; for as to the Hour Circles, they are all feen in Cultro, (that is to fay, they lye directly under your Eye, and consequently are in projection streight Lines, and distant (as on the Sphere) 15 Deg. asunder; I say, since the Rule agrees not a little with this way, and that I have done with the great Circles both Planes, I will now demonstrate it by the two Lemmas that follow.

The Demonstration.

He Secant of any Arch is equal to the Tangent of the Lemma I. Same Arch more by the Tangent of half its Comple- E ment. That is to fay, CE the Secant (for example sake) of 60 Degrees (in Scheme 5) is equal to EB (the Tan-Sasgent of 60) and to BA the Tangent of 15, or half the Complement of 60: For the Angle ECA being equal by Hyp. to the Angle ACH, becomes equal to * the Angle EAC. therefore EA is equal to † E C, and consequently EB plus B A is equal to EC. QED.

II. The Tangent of any Arch greater than 45 Degrees is equal to the Tangent and Secant of double its Excess above 45 Degrees; that is to fay, AB Tangent (for example) of 46 Deg. (in Sch. 6th) is equal to CD Secant of 2 Degrees plus DB Tangent of the said Degrees; for the Angle DCA being by Hyp. † equal to the Angle ACH becomes equal to the †Eucl. 27.1.



*6. I.

Angle DAC; therefore CD is equal to * AD, and conse-

quently AD plus DB is equal to CD plus DB.

The Ecliptic truly proje-

These two Lemmas being premis'd, let us consider the Projection (for example fake) of the Ecciptic, and fee how it agrees with our said Rule, towit, That the Centers of all the projected great oblique Circles are distant from the Center of the Projection, the Tangent of as many Degrees as their Poles are distant from the Pole of the Plane on which the Projection is made and that the Secant of those Degrees gives their Radius's. Ecliptic is to touch both Tropies on the Solftitial Colure or Meridian of the Plane, because it touches that Colure thus in the Heavens, and on the Sphere; so that by Construction P 5 (the distance in Projection between the Center of the Plane and the Point where the Ecliptic touches the Tropic of Cancer) is the Tangent 33. 15'. or half 66. 30', (its real distance on the Sphere from the North Pole) and on the other fide P' (the distance in Projection between the Center and the Point where the Ecliptic touches Capricorn) is the Tangent of 56.45. or half 113. 30'. its real distance as before. Now D by Construction being distant (on the Meridian or Diameter of the Plane) from the Center P the Tangent of 23 d. 30 m. (or real distance between the Pole of the Plane of the Projection and that of the Ecliptic) must needs be, according to our Rule, the Center of this Circle in Projection, and the Secant of those Degrees its Radius, if we prove the said D to be the middle of the Line 5 19 (or Diameter of the Ecliptic) and D 5 and D 19 to be Secants of 23 d. 30 m.

'Tis manifest that D 5 is Secant of 23 d. 30 m. because'tis equal (by Lem. 1.) to PD, Tangent of 23 d. 30 m. plus P 69 Tan-

gent of 33 d. 15 m.

Again DW is Secant of 22 d. 30 m. because P W (Tangent of 56 d. 45 m.) is equal by Lemma the second to the Tangent and Secant of 23 d. 30 m. Now P D being Tangent of those Degrees, DW must be Secant; therefore DS and DW being equal, D is the middle of the Line S, W, and consequently P D (the Tangent of 23 d. 30 m. from the Center of your Plane) gives in its Meridian the Center of the Ecliptic, and the Secame of those Degrees the Radius, Q. E. D. and in this maner the way of projecting the other great oblique Circles is to be demonstrated.

Nor do's this Rule solely serve for the Description of the A Memorangreat Oblique Circles on the present Planes, but for all that are dum. expressed on Stofflers Astrolabe, or Mr. Oughtreds Horizontal; Nay it shews not only how to draw the Meridians in Gemma Frisius his Projection, but, by the bare conversion of the Terms, the Parallels themselves, tho little Circles.

For first as to the Meridians, whose Poles, (as every body The way of deknows) lye all in the Aquator, suppose you would describe scribing G. the 10th. from the Limb or grand Meridian, which is to be the Frifius's Me-Solftitial Colure, fince, in this Projection, your Eye lies in the ridians. East or West points of the Aquator, to wit in the Pole of the faid Colure; I say, suppose you were to describe the 10th. from the Limb, it follows by our Rule, because their Poles are 10 Degrees asunder on the Sphere and in the Heavens, that the Tangent of those Degrees gives from A (the Center of the Projection in Sch. 7th.) the requir'd Center B, and the Secant the Radius; For this Circle on the Sphere cutting the Aquatorat the 80th. Deg. from the Pole of your Plane, (or point opposite to sch ? your Eye) its extremit, C must in Projection be distant from A the Tangent of 40 Deg. only; Now fince B C(to wit B A plus-A C the Tangents of 10 and 40 Deg) is equal by Lemma the first) to the Secant of 10 Degrees, and fince BN. and BS for distance from B to the two Poles of the World) are visibly the Secants of those Degreees, it necessarily follows, that the Meridian to be describ'd (which pass we know throu' the said three points C.N. and S.) can have no other Center but B, nor Radius but the faid. Besides if if we make this Arch an entire Circle (by the prickt Arch N ÆS) then AB the Tangent of 10 Degrees plus B Æ = BC (the Secant of 10) is equal (by Lemma the 2d. to the Tangent of 50 Degrees, but the other part of the said Meridian Iyes (we know on the Sphere) 100 Degrees from the forementioned Pole of the Plane, and in projection the Tangent of 50 from the Center A; ergo B is the true Center of the requir'd Meridian, and the Secant of 10 Degrees the Radius.

2. For the Parallels or Circles of Latitude, the same The way of Rule (the Terms as I faid being converted) finds both describing their Centers and Radius's; for if you would project (suppose) G. F. b.s Pa-the 80th. Parallel from the Aquator, that is to say, the 10th. from the Pole of the World, 'tis but faying, That the Secant of

10 Degrees from the Center of the Plane gives you the Center of the Parallel requir'd, and the Tangent of the same Degrees the Radius. To prove this, let A F (in Sch. 7.) be by Construction the Secant of 10 Degrees, and opening your Compasses at the Tangent of those Degrees place one foot on the said F, and describe the Circle KLPO; Now because AF the Secant of 10 Degrees is equal (by Lemma the 1st.) to the Tangent of 10 and Tangent of 40 Degrees, therefore AK is the Tangent of 40 Degrees. Again because AF (Secant of 10) plus FP = FK(Tangent of 10 Degrees) is (by Lemma the 2d) equal to the Tangent of 50, ergo AP is Tangent of 50; but the Parallel requir'd is a Circle which on one side cuts (in the Sphere) the Aquinoctial Colure 80 Degrees from the Pole of your Plane (or point opposite to your Eye) and on the other side at 100, or supplement of the said 80 Degrees, therefore seeing K and P the two extreme points of the projected Circle OPLK are distant from the Center A on the produc'd Axis (or intersection of the Equinoctial Colure with the Plane) the Tangents of 40 and 50 Degrees (to wit, the Tangents of half the real value of these Arches) it must follow that the said OPL K truly represents the requir'd Parallel, and consequently that the Arch OK L is that part of it, which is farthest from your Eye, to wit, so much of the whole Circle as falls on the Plane. Thus much then for these Parallels, since all are to be describ'd after the same manner, and now having mention'd little Circles. 'tis fit the Reader should know how the Circles of Altitude are to be describ'd on the second Plane of the Pedestal or Projection which are little Circles alfo.

cribe the Cir-Plane.

The way is easy for if you would have the Almucantar, How to des- (suppose) of 10 Degrees (viz. abcd in Scheme 4th) you cles of Alti- must proceed thus. Because the Horizon in projection (as we sude on the 2 show'd you before) is distant from the Center, (on the North side of the Meridian) the Tangent of 25, 45m. or half the Elevation, to wit from P to H, and (on the South side) from P to S, the Tangent of 64. 15, or half 128. 30'. the Supplement of the said Elevation, therefore the Almucantar of 10 Degrees (being on the Sphere 10 Degrees neerer the Pole than the Horizon,) will in projection be nearer the Center 5 Degrees. So that the Tangent of 20, 45 from the Center P giving (a) its extremity on the North side of the Meridian, and the Tangent of 59.15. giving (c) its extremity on the South side, it follows that (g) half the diffance between the said(a) and c becomes the Center to describe it by; For since all the Circles of the Sphere. are still Circles in projection (except those that are seen in Cultro (as we said) if you have the Diameter (or streight Line that joyns the extreme points of any of them) half of it must needs give you the Center; and in this manner then are the other (ircles of Altitude, to be describ'd. But here take notice that whereas in Sch. 2. (representing the second or trasparent Plane) the Azimuths and Almucantars are found (as I show'd * 1.138 and you) by the consideration of the Pricks or Asterisks there express:

Now, that the Reader may know how to Place them, the very (ircles and Arches are describ'd on it, Sch. 4. as it represents for the said Pricks and Asterisks are ever to be in their intersections. And by way the Instrument maker may (if he pleases) make use of Pricks, and no Asterisks on the real Transfparent Plane of the Pedestal; for they will upon second thoughts perform better the Operation.

The Conclusion.

fent occur, I shall now end with what I promis'd in the * Beginning, to wit, with showing the Reader the * p. p. particular Advantages of this Globe, which are of sour kinds; For, First it does several Operations not performable by the Ordinary Globes. 2ly. It does even the Operations (which the other perform) much easier and quicker. 3ly. It performs many at a view, which are to be done by the other (for the most part) successively. Lastly, It has several by-advantages and conveniences belonging to it by it's Make independent of the Operations.

As to the Operations not performable by any other Globe, they First kind.

1. The placing of it self * Level, or Horizontal. * pag. 4.
2. The \$\pmoleon Composing of it self to the Position of the Heavens. \$\pmoleon pag. 4.
3. The showing of the * Hour, even several wayes: and the \$\pmoleon pag. 13.

not only at Home but at the same time a'so in all ‡ Places ‡ P. 31.

of the World.

*pag. 36.

4. The knowing how much any place wants of Day, if it be
Night there; or of Night if Day there; and consequently the # Babilonish and Italian Hour without any Compu- # pag. 39.
tation.
* p. 40.

5. The shawing the * Judaical Hour, without any Computation.
6, The

150 The Descript, and use of the English Globe. § 6.

* p. 35.

6. The showing the Sun's true Place in the Heavens every Moment, and consequently in what Countrey he is then Vertical.

7. The Sun's beight at any time of the Day both at * home, and in all other ‡ Places, where the Globe show's 'tis Day, as also his Depression where it show's 'tis Night.

8 The Sun's * Azimuth and + Bearing.

9. The Antient * Geography as well as Modern.

10. The Hour by the ‡ Moon; with several other Operations concerning her.

11. The * proportion of Perpendiculars to their shades, with Corollaries in relation to Altimetry, and showing the Hour by your stick.

12. The performing of all the accidental*Requisites to Dialling, as how to draw Meridian Lines, and Lines Parallel to the Horizon, how to find the Declension of all Planes, as also their Reclination, Inclination, &c.

But here the Reader must remember, that when I say none of the forementioned Operations are performable by other Globes, I mean not this alwayes in a strict sence; for if (suppose) we have the Hour of the Day given, we may then (as every body knows) soon find by it the Sun's height, or if (suppose) we have his Azimuth, we have the Hour; I say, I mean not this alwayes in a strict Sence, but call all these Operations not performable by other Globes, since they at first require (for the Operations they do) somthing as hard to be found as what we seek after; whereas by exposing only of this Globe to the Sun, and having but the day of the Month, most of the Premises present themselves to us at all times with as much sacility as the very Hour it self by an Horizontal Dial.

Besides, the Reader must know, if a Brazen graduated Semi-Circle were hung on the Poles here, with an erected moveable Pin, or Cursor on it, there would be no need of the Holes (I* formerly mention'd) in each Parallel of the Globe, for the true Composing of it; Nay this Semi-Circle (omitting several other things) will also give the hour, by being still directly over it, as often as 'tis moved into the Plane of the Sun; but seeing I pretend to show all the Operations here treated of, even on a naked and free Globe, by the sole help of a little String or Tred, I hint only the said Semi-Circle, that the Reader may

* p. 70.

* p. 5.

7. 37.

*0.10.

* p. 21.

+ p. 5 1.

* p. 65.

A Memorandum.

* p. 8.

use it, if he shall judge it any time fit for his business.

In the second place, as to the Operations common to all 2d kind. Globes, but more easily perform'd by this, take some sew Ex-

amples that follow.

1. If you would find (suppose) the Aurora by the Common Globes, you must (atter knowing the Day of the Month, or Suns place in the Ecliptic) bring it to the Meridian; then you must put the Index Horarius on 12, and so move the said Sun's place to the East side of the Horizon. Afterwards you must find the opposit Point to the Sun's place, and fixing your Quadrant of Altitude in the Zenith; you must mount the said opposite Point till it meet with the 18th Degree, and then the Index gives you what you seek for, whereas by This Globe you have nothing to do but to * depress your Bead 18 Degrees be * p. 18. low the Horizon, and to move the String on the Zenith till the said Bead touches the Parallel of the Day on the East side of the Globe; for then it lyes on the requir'd Hour.

2. If you would but know when the Sun rifes by the other Globes; you must (after finding of the Sun's place) lay your Index on 12 and when you have brought the said Place to the East side of the Horizon, the Index will show the Hour: Whereas now the * Intersection of the Parallel of the day with the Horizon performs the Operation without more a-doe.

ther Globes, you must first find the Right Ascension, then you must find the Oblique, and lastly you must substract the greater from the less; where is here the distance on the Parallel of the day (which the Hur Circles measure) between the 6 a clock hour circle and the intersection of the said Parallel with the Hisizon gives at a view the requir'd Ascensional D sterence in time, and consequently in Digrees. I shall not trouble my Reader with more Instances at present, leaving the rest to his own Observation, and he will still find (at least generally speaking.) That the Operations (as I said) common to both Globes are more easily and readily perform'd by this than by any other.

As to the Advantages of the third kind, to wit, The performing several Operations at one view, which are perform'd successively by other Globes, there are at least 15 that present themselves to you (the Globe being compos'd) as soon as ever you have made the Shade of the String (hanging on the Zenith) to

bind

152 The Descript. and Use of the English Globe. § 6

pass throu' the Nadir; for then you have before your Eyes.

* p. 14.

1. The Hour of the Day; by considering the shade of the *illuminated Pole.

2. The Day of the Month; by considering on what Diurnal Parallel the Shade of the String marks the same Hour with that

P. 15. Shewn by the shade of the Said illuminated Pole.

* p. 16.

* p. 17.

3. The Place where the Sun is Vertical; by considering the sun's * place in his Parallel, and consequently the Country under it.

4. The Sin's Sign or Place in the Ecliptic; by confidering (according to the Increment or Decrement of the Days) throw what part of the * Ecliptic the Parallel of the Day passes.

*p. 13.

*p. 11.

5. The Suns Declination; by considering throw what * Degree of the Equinoctial Colure, the Parallel of the Day passes.

*p. 10. 312 6. The Sun's Azimuth and Bearing; by considering what * Degree of the Horizon and what Nauti cal Character, are cut by the shade of the String hanging from the Zenith.

7. The time of the Sun's Rising and Setting; by considering on what * hour circle the Parallel of the Day and Horizon intersect on the East and West sides of the Globe.

8. The length of the Day and Night; by considering bom many Hour-Circles cross that part of the Diurnal Parallel which is above the Horizon; for they show the length of the Day, as the Hour-Circles, that cross the part under the Horizon, do the length of the Night.

*p. 19. Mour-Circles on the Parallel of the Day between the 6 a clock Hour-Circle, and the intersection of the Said Parallel with the Horizon.

* p. 17. The Sun's Amplitude; by considering how many * Degrees in the Horizon the Sun rises from the true East Point, or sets from true West.

* p. 33. Where 'tis Day or Night over all the World; by considering the *illuminated and obscur'd parts of the Globe; for the one show's ever where 'tis Day, and the other where 'tis Night.

* 1. 33. but Night: by considering the * Illumination and Obscuration about

about the Poles: for a Circle describ'd about the illuminated Pole, to the nearest shade of Extuberancy, shows, that all the Inhabitants within that Circle have nothing but Day, and that all they that dwell within the like Circle about the obsour'd Pole, bave nothing but Night.

ver; by considering the * preceeding and following shade of Ex- * p. 34. tuberancy; for the first, show's the people to whom the Sun then

is Rising, and the other to whom the Sun is then Setting.

14. How many hours any place wants of day or night; by confidering first a Parallel to run over the Place propos'd, and then by reckoning the number of * Hours between the said place, and the * p. 36. preceeding, and following skade of Extuberancy; the one bringing with it Day and the other Night.

15. What a clock 'tis all the World over; by considering (according to the little Polar Figures) the * Hour-Circle that * p. 31. passes over any place, and adding to the time thus found (if it be in the afternoon) as many hours as are past since Midday with you, or substracting (if it be in the Morning) as many Hours as you want of Midday.

Now for the last kind of Conveniences, which this Globe 4th kind. Challenges, to it felf, to wit. Those independent of the Operations,

they are 4.

1. For, First It takes up little or no room wheresoever it stands, the bottom of the Pedestal not being ordinarily much bigger, than the foot of a large hour-glass, whereas other Globes are cumbersom, and embarras any Table or Place on which you set them.

2. It is wholly expos'd to our Eye as well below as above the Horizon; whereas the Frame, Meridian, and the other Appendices of common Globes, always hide more than half of them.

3. It is as cheap as a single ordinary Globe, and yet performs

the Operations of the Terrestrial and Celestial ones.

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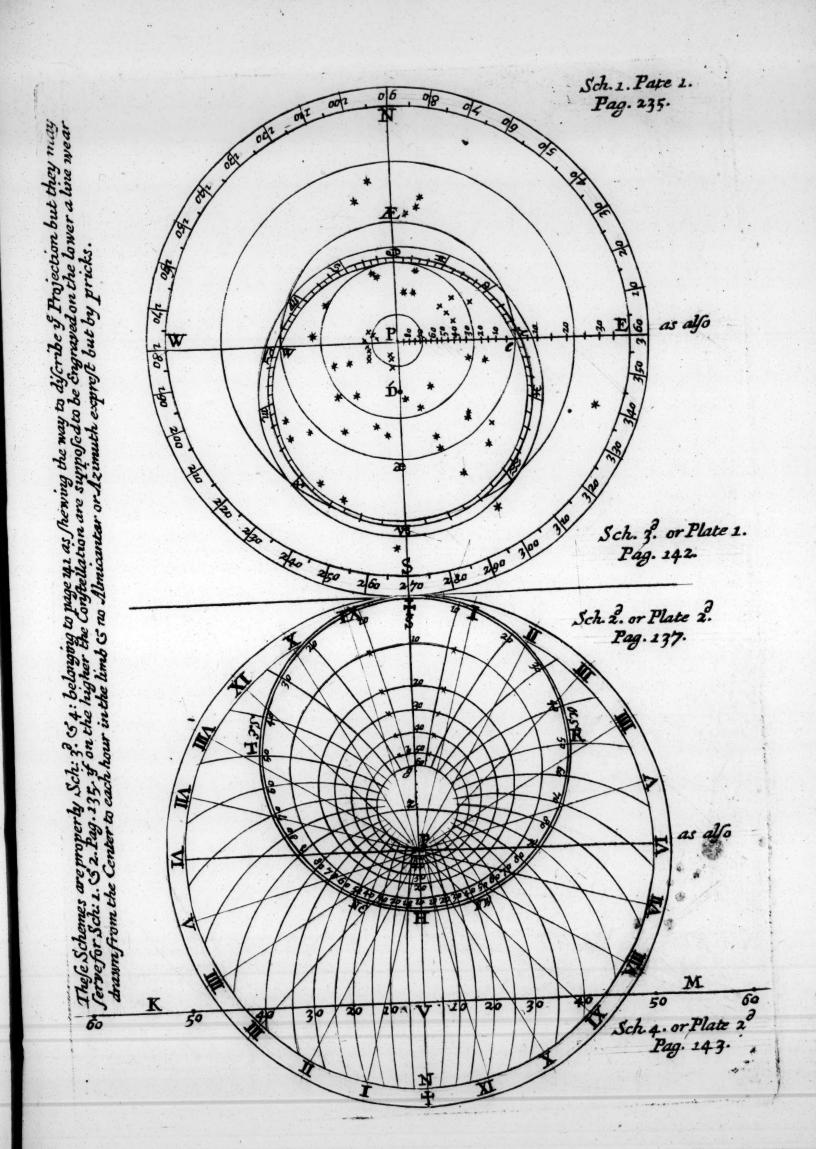
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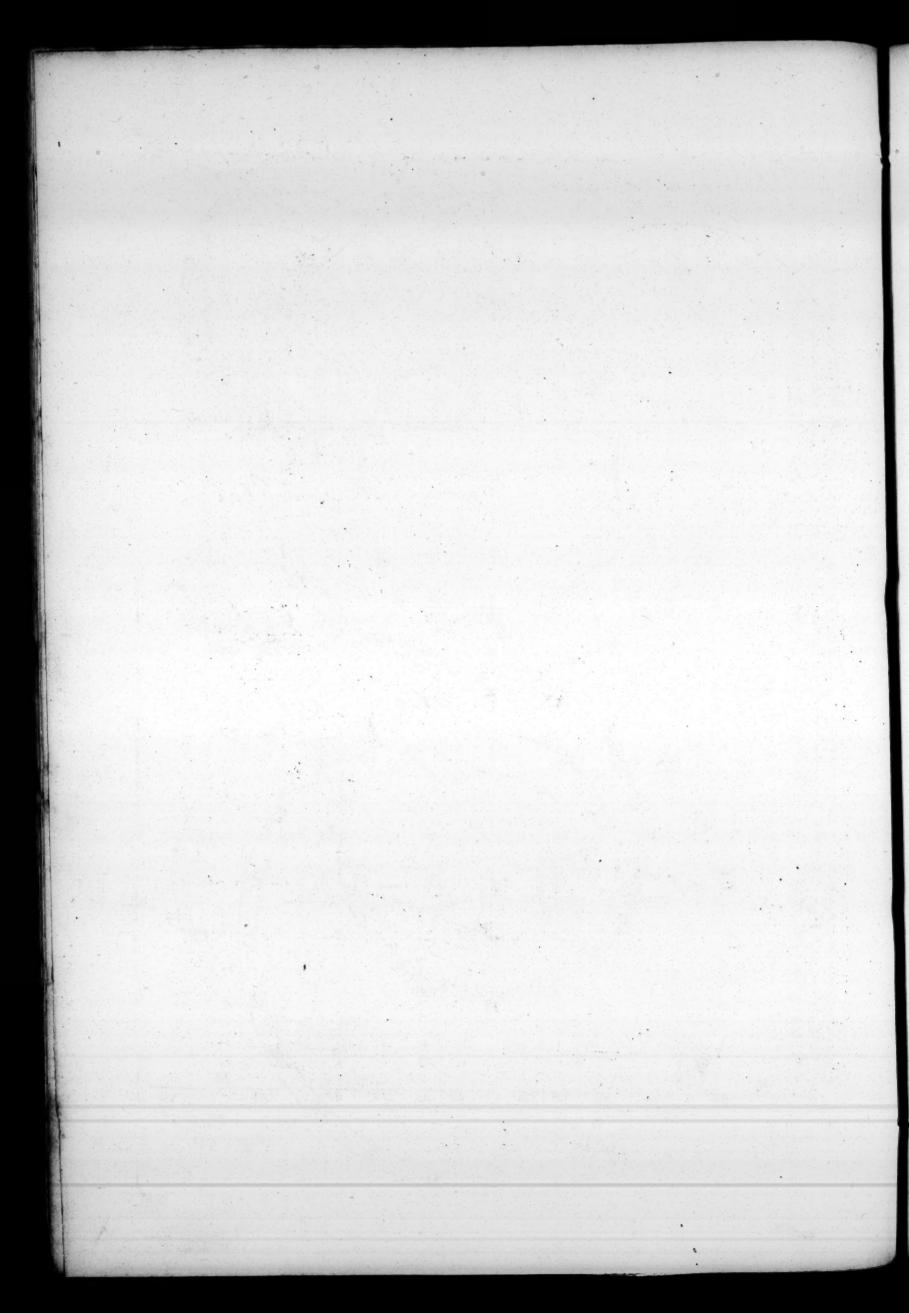
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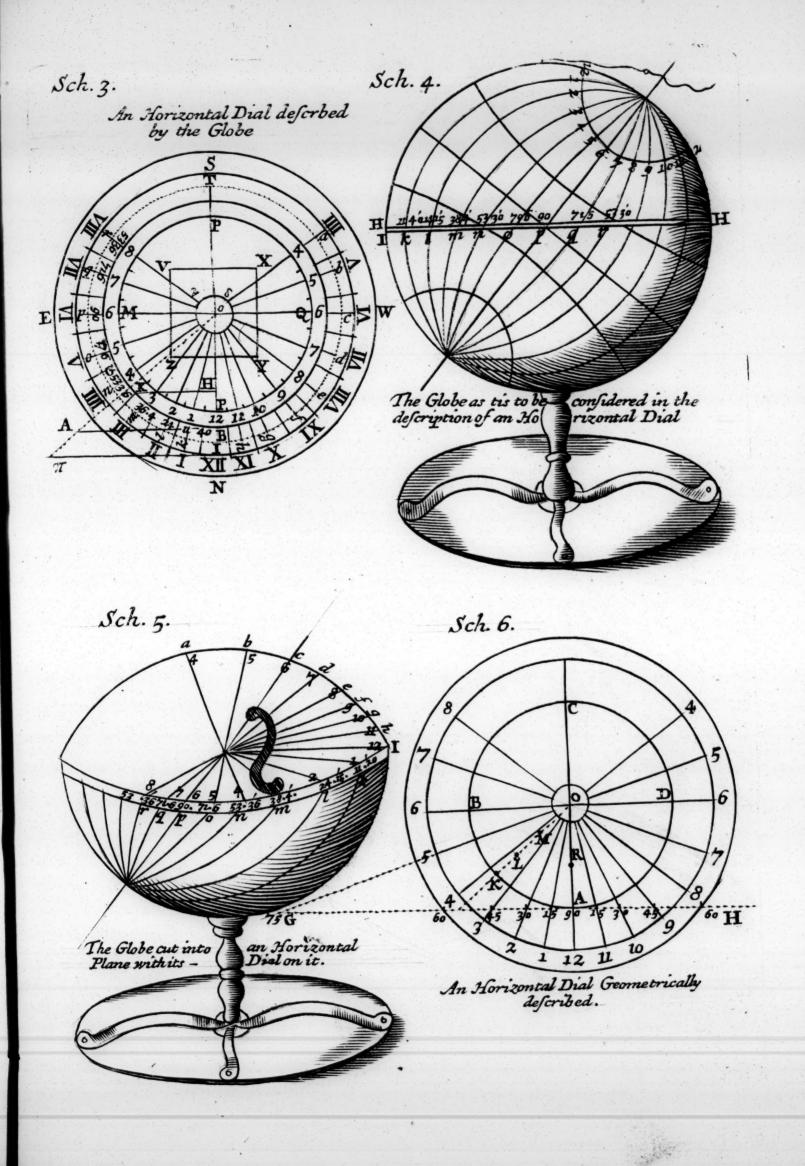
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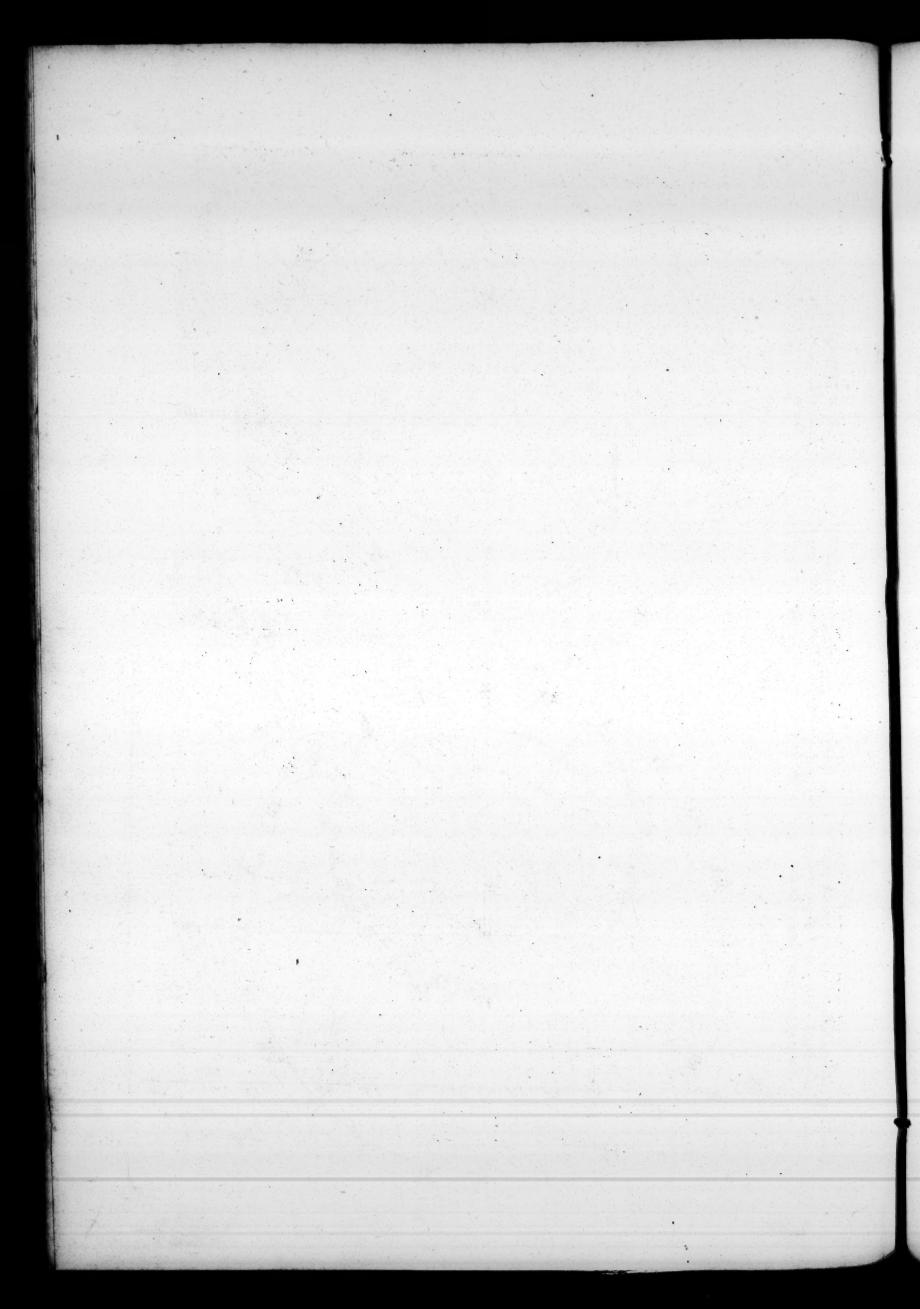
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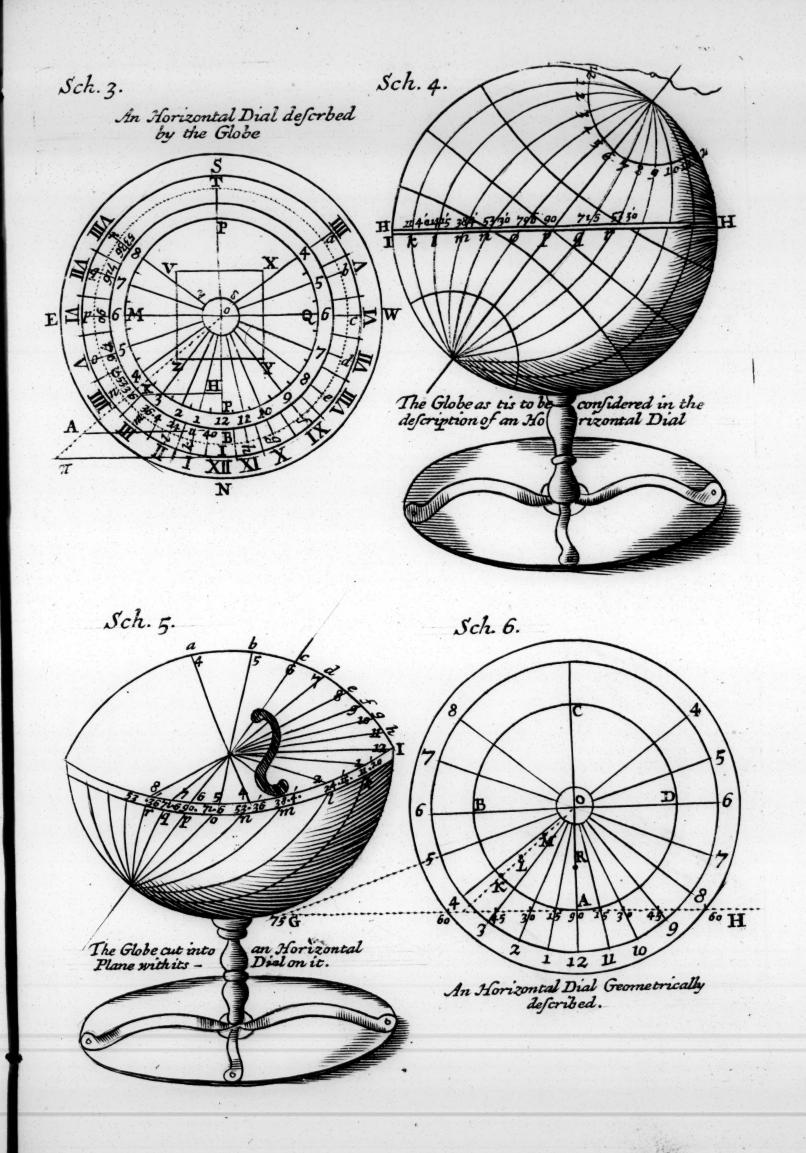
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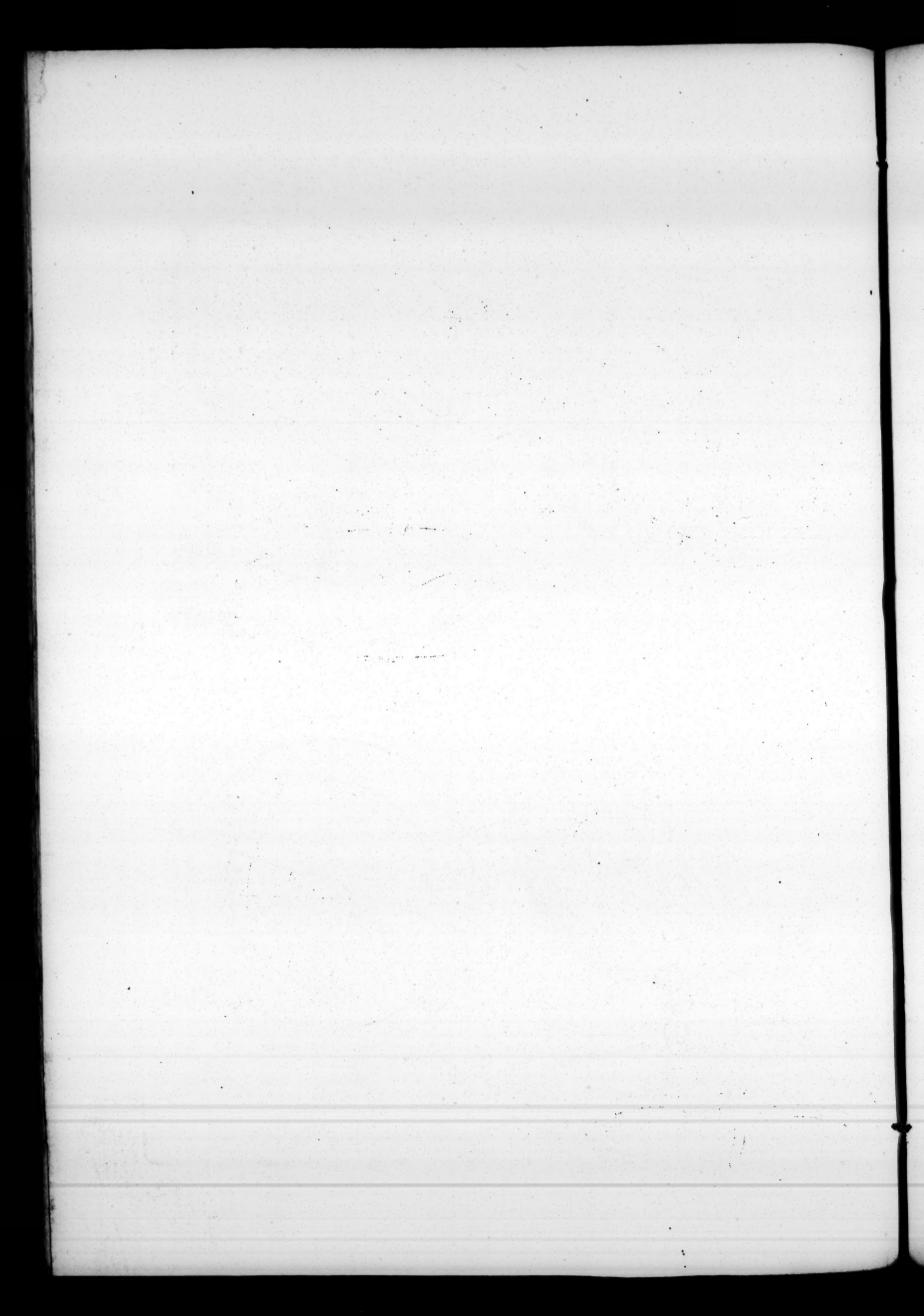




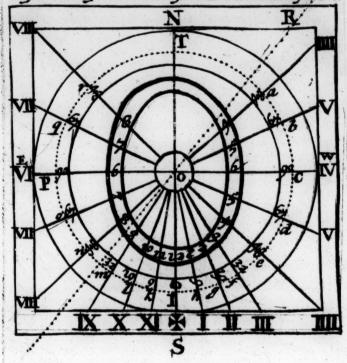






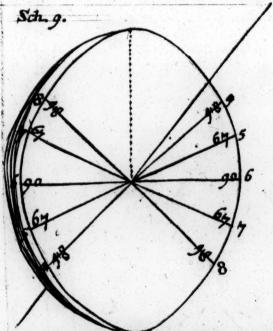


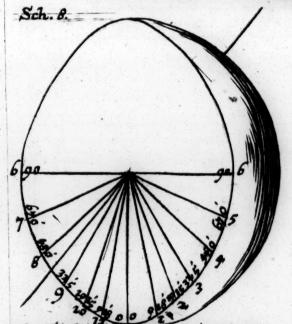
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